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PSTIAC REPORT NO. 4

# A BIBLIOGRAPHY WITH ABSTRACTS OF U. S. ARMY ENGINEER WATERWAYS EXPERIMENT STATION PUBLICATIONS RELATED TO TERRAIN

by

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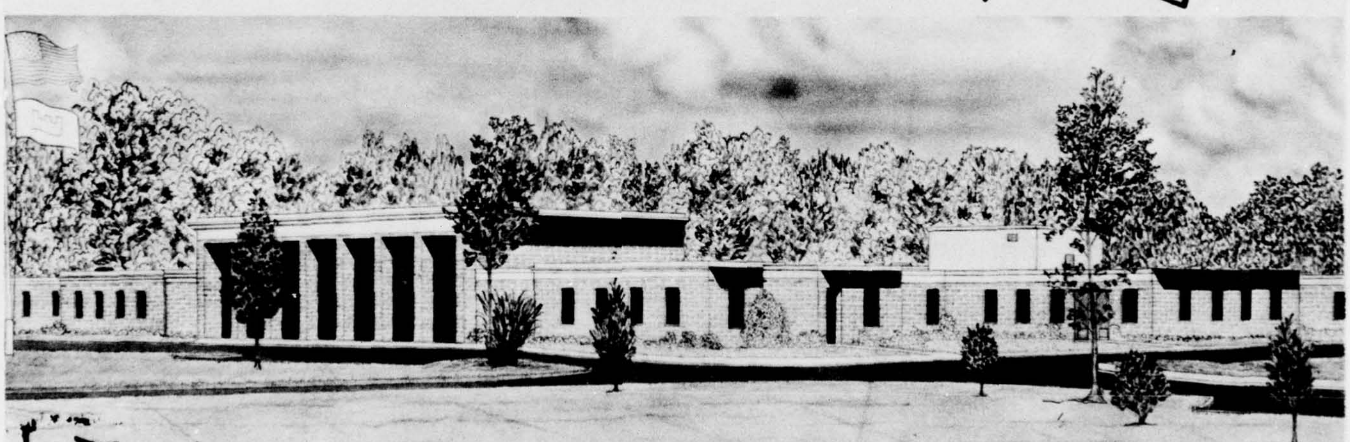
June 1977







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**20. ABSTRACT (*Continue on reverse side if necessary and identify by block number*)**

The reports listed herein were published from 1951 through 1976 by personnel of or under contract to the Waterways Experiment Station. Indexes are included by subject, personal author, corporate author of contract reports, region, and military base. One part includes Document Control Data - R&D, or Report Documentation Page data that includes abstracts for each report.



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PREFACE

This This publication is a bibliography, with abstracts, of unclassified reports on terrain covers reports published from 1951 through 1976 by the U. S. Army Engineer Waterways Experiment Station (WES). Most of the reports were prepared by personnel of or under contract to the Mobility and Environmental Systems Laboratory (MESL) of the WES; some of the reports were prepared by personnel of the Soils and Pavements Laboratory. Indexes are included by subject, personal author, corporate author of contract reports, region, and military base. One part contains Document Control Data -- R&D or Report Documentation Page data (DD Form 1473) that includes abstracts and other pertinent bibliographic information for each report.

The reports relate to the characterization and remote sensing of terrain as applied generally to military operations in research and development studies.

The reports have been distributed primarily to the sponsor and certain other agencies having an interest in the work reported. Most of the reports, particularly those published prior to 1970, are out of print. Available copies will be furnished without charge to Federal Government agencies on request until the supplies are exhausted. Reports with AD numbers can be obtained by Department of Defense agencies from the Defense Documentation Center; other agencies and individuals can obtain copies from the National Technical Information Service (see following paragraphs for additional information). Reports prefaced with the footnote "Statement B. See Preface" are limited in distribution or loan to U. S. Government agencies only unless permission for release can be obtained in special cases from the controlling office.

Library copies of the reports are available for loan from the WES Library Branch to Department of Defense agencies. The library loan privilege is extended to other Federal and state agencies, and except those restricted as described above, to scientific and educational institutions and established engineering or industrial firms. In such cases the loan period is usually limited to 30 days. Private individuals not connected with the Department of Defense can usually arrange

for library loan either through the main offices of their business concerns or by having their local libraries arrange for interlibrary loan. Lending to persons outside the United States is not encouraged because of the extended time periods involved and risk of loss of publications in transit.

All matters concerning the distribution or loan of WES publications should be addressed to the Director, U. S. Army Engineer Waterways Experiment Station, ATTN: WESTV, Post Office Box 631, Vicksburg, Miss. 39180. Matters concerning the technical content of the reports should be addressed to the same address, ATTN: WESFV.

Except for a few reports, the WES no longer sells its publications. Reports listed in this volume having AD numbers can be purchased in microfiche or hard copy from the National Technical Information Service, U. S. Department of Commerce, 5285 Port Royal Road, Springfield, Va. 22161.

This bibliography was compiled by Mr. Marvin P. Meyer, Director, Pavements and Soil Trafficability Information Analysis Center. Stenographic assistance was provided by Mrs. Jane Brown, MESL. Miss Virginia Dale and Mrs. Rosemary Peck, Technical Information Center (TIC), assisted in organizing the Report Document Page data. Mr. Woodland G. Shockley, Chief of the MESL, and Mr. Bob Benn, Chief, Environmental Systems Division, MESL, were responsible for overall supervision of the work. Mr. Alan G. Skelton, Chief of the TIC, supervised work conducted by TIC personnel. The U. S. Army Materiel Development and Readiness Command provided funds for the report.

COL J. L. Cannon, CE, was Director of the WES, and Mr. F. R. Brown was Technical Director during the report publication.

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## ABBREVIATIONS

| | |
|---|---|
| CR | Contract Report |
| IR | Instruction Report |
| M | Mobility and Environmental Systems Laboratory Report |
| MP | Miscellaneous Paper |
| NCG | Nuclear Cratering Group Report |
| PSTIAC | Pavements and Soil Trafficability Information Analysis Center Report |
| S | Soils and Pavements Laboratory Report |
| TM | Technical Memorandum |
| TR | Technical Report |
| U-7/70 | Unnumbered Report - Month/Year of Publication |
| WES | Waterways Experiment Station |

PART I

LIST OF REPORTS

MOBILITY AND ENVIRONMENTAL SYSTEMS LABORATORY

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| 3-240 | | Trafficability of Soils | | |
| | Aug 1954 | Supplement 11 | Superseded by Supplement 16 | |
| | Dec 1956 | Supplement 14 | A Summary of Trafficability Studies Through 1955 | AD 121 975 |
| | Aug 1961 | Supplement 16 | Soil Classification | AD 265 743 |
| 3-331 | | Forecasting Trafficability of Soils: | | |
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| | Oct 1954 | Report 3 | The Development of Methods for Predicting Soil Moisture Content: | |
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| | Feb 1957 | Report 4 | Information for Predicting Moisture in the Surface Foot of Various Soils | |
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| 3-588 | | Project Otter (Overland Train Terrain Evaluation Research): | |
| | Dec 1961 | Report 1 Pretest Report | AD 402 257 |
| | Feb 1965 | Report 2 Test Report, by J. H. Shamburger and L. M. Duke | AD 613 166 |
| 3-609 | Aug 1962 | Operation Swamp Fox I, Terrain and Soil Trafficability Observations | AD 290 529 |
| 3-612 | Nov 1962 | A Technique for Mapping Terrain Microgeometry | AD 295 473 |
| 5-625 | May 1963 | Environmental Factors Affecting Ground Mobility in Thailand; Preliminary Survey | AD 411 528 |
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| 3-630 | | Analogs of Yuma Terrain | |
| | Feb 1958 Revised Jun 1962 | Report 1 Analogs of Yuma Terrain in the Northeast African Desert | |
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| | Sep 1966 | Report 2 Radar Responses to Laboratory Prepared Soil Samples, by J. R. Lundien | AD 802 104 |
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| | Nov 1970 | Report 2 | Gamma-Ray Techniques for Nondestructive Measurements of Soil Density and Density Profile, by A. N. Williamson | AD 715 980 |
| M-71-3 | | Environmental Characterization of Munitions Test Sites, by H. W. West, R. R. Friesz, E. A. Dardeau, G. F. Brown, L. E. Couch, and J. A. Parks: | | |
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| M-74-5 | | Computer-Calculated Geometric Characteristics of Middle-Mississippi River Side Channels: | |
| | Jun 1974 | Volume I Procedure and Results, by V. E. LaGarde and S. J. Winfrey | AD A031 773 |
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13. ABSTRACT

The purpose of this study was to produce means of estimating the trafficability of soils according to their identification in the Unified Soil Classification System described in Waterways Experiment Station Technical Memorandum No. 3-357, "The Unified Soils Classification System," dated March 1953. The study was limited mainly to the analysis of trafficability tests conducted since 1945 by the Waterways Experiment Station.

KEYWORDS: Soil strength; Statistical analysis; Trafficability classification

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13. ABSTRACT

The trafficability factors, bearing and traction capacity, are functions of shearing strength. A simple instrument, the cone penetrometer, measures an index of shear strength. Cone indexes on fine-grained soils and sands with fines, poorly drained, are related to vehicle performance, but an auxiliary test, remolding, must accompany the cone penetrometer test to predict changes in cone index under traffic. Slipperiness and stickiness cannot be measured, but can be anticipated approximately from simple soil tests. Tests with wheeled vehicles on sands showed fair correlation between maximum slope and cone index with tire pressure duly considered. Means are presented for: classifying soils from the trafficability standpoint; computing cone index required for any military vehicles; quickly estimating maximum slopes vehicles can climb, maximum tow loads, and towing forces required on various soil strengths; making actual trafficability measurements and mapping them for strategic and tactical purposes; and for estimating trafficability without contact with the soil.

KEYWORDS: Military vehicles; Mobility; Soil strength; State-of-the-art studies; Trafficability: Trafficability classification; Trafficability mapping; Trafficability prediction

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Meyer, M. P.
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13. ABSTRACT

A statistical analysis was made of soil strength (cone index, remolding index, and rating cone index), soil moisture, dry density, and percent saturation for soils classified according to the Unified Soil Classification System (USCS) and U. S. Department of Agriculture (USDA) classification system. Data were obtained during wet-season periods from more than 1300 sites located principally in humid, temperate regions of the United States. Soils of high- and low-topography positions were analyzed for average and high-moisture conditions in the wet season. The information was used to improve an existing scheme for classifying soils according to their trafficability. A comparison of USCS and USDA soil types was made for the 6- to 12-in. layer of soils, and a study was made to compare the type of soil in the 0- to 6-in. layer with the type in the 6- to 12-in. layer of the profile, in USDA terms. Two appendices describe data sources and test procedures.

KEYWORDS: Soil strength; Statistical analysis; Trafficability classification; Trafficability data

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13. ABSTRACT

The investigation of soils trafficability as related to mobility of military vehicles is divided into three phases as follows: (1) soils classification and trafficability data or the development of methods and instruments for determination of trafficability by ground reconnaissance parties; (2) soils trafficability predictions or the development of methods to correlate soils trafficability with weather data sufficiently accurate to enable military planners to forecast the trafficability of soils in an area without physical tests; and (3) crossing areas of mud, sand, or unstable terrain or the development of portable roadways and construction of roadways from local and other materials for crossing very soft areas. The Waterways Experiment Station has been assigned investigation of the first two phases. This report describes the first studies conducted under phase (2), based upon the following premise: both the cone index and the stickiness vary primarily with moisture content; therefore, a correlation between these factors and climate appears in order if forecasts of soil trafficability are to be made.

KEYWORDS: Meteorological data; Soil data; Soil moisture prediction; Trafficability prediction; [Vicksburg, Mississippi]

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13. ABSTRACT

This is a continuation of the study started and reported upon in Report No. 1 of this series of reports. Many valuable suggestions for refining the forecasting techniques presented in that report are incorporated in this one.

KEYWORDS: Meteorological data; Soil data; Soil moisture prediction; Trafficability prediction; [Vicksburg, Mississippi]

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10. AVAILABILITY/LIMITATION NOTICES
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| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY |
|---|---|
| U. S. Forest Service collaborated in this study. | Chief of Engineers, DA Washington, D. C. 20315 |

13. ABSTRACT
This is a continuation of the study reported upon the first two reports of this series. It comprises three volumes and an appendix. Volume 1, prepared jointly by the Waterways Experiment Station and the U. S. Forest Service, gives a summary and comparison of prediction methods, and an account of current work and that planned for the future. Detailed descriptions of the Forest Service prediction methods and experimental procedures used at Vicksburg are given in volume 2. Predictions developed by the Forest Service for other areas are given in volume 3, together with results of correlation studies and a description and application of the Waterways Experiment Station prediction system. Results of special studies and basic soil-moisture and weather data are presented in the appendix.

KEYWORDS: Meteorological data; Soil data; Soil moisture prediction; Trafficability prediction; [Vicksburg, Mississippi]

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3. REPORT TITLE
FORECASTING TRAFFICABILITY OF SOILS: INFORMATION FOR PREDICTING MOISTURE IN THE SURFACE FOOT OF VARIOUS SOILS

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
Report 4 of a series.

5. AUTHOR(S) (Last name, first name, initial)
Carlson, C. A.
Horton, J. S.

| 6. REPORT DATE | 7a. TOTAL NO. OF PAGES | 7b. NO. OF REFS |
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| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY |
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| U. S. Forest Service collaborated in this study. | Chief of Engineers, DA<br>Washington, D. C. 20315 |

13. ABSTRACT

Site characteristics, soil properties, climate, and all information needed for soil-moisture predictions from the 131 sites, representing a wide variety of American soils, used in development of the soil-moisture prediction method are given. Accuracy of the prediction method was tested for every site by comparing predicted moisture contents to actual soil-moisture records. Sixty-five sites for which deviations were computed for every day had an average deviation of 0.08 in. of moisture for the 0- to 6-in. layer and 0.06 in. for the 6- to 12-in. layer. Deviations for 45 sites with comparisons of only before- and after-storm moisture contents averaged 0.13 in. and 0.10 in. for the two layers. As a second method of comparison, prediction relations developed from one year's record were used to predict soil-moisture content for the next year. Generally, deviations of predicted from actual for the second year averaged about the same as for the first year. Present status of the project and recommendations for future studies are outlined.



KEYWORDS: Soil data; Soil moisture prediction; Trafficability prediction


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3. REPORT TITLE
FORECASTING TRAFFICABILITY OF SOILS; DEVELOPMENT AND TESTING OF SOME AVERAGE RELATIONS FOR PREDICTING SOIL MOISTURE

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
Report 5 of a series

5. AUTHOR(S) (Last name, first name, initial)
Carlson, C. A.
Horton, J. S.

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| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY |
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| U. S. Forest Service collaborated in this study. | Chief of Engineers, DA<br>Washington, D. C. 20315 |

13. ABSTRACT

Detailed observations made in previous studies of sites distributed throughout the United States were used to derive average soil-moisture relations for use in applying previously developed soil-moisture content prediction methods to sites for which no specific data on the moisture regime are available. The average relations were tested on 24 sites that had been used in the development of prediction method, on 10 sites for which soil strength and moisture data were available, and on 617 sites located throughout the United States for which detailed data were not available. Predicted and measured values were compared, and the accuracy of prediction of soil moisture was within reasonable limits of error for well-drained soils. Appendices give the prediction method developed and a sample of its application, describe the 617 sites with limited data used in this investigation, and present results of special studies made to improve the accuracy of the prediction method.

KEYWORDS: Soil data; Soil moisture prediction; Trafficability prediction

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| 3. REPORT TITLE<br>FORECASTING TRAFFICABILITY OF SOILS: AIRPHOTO APPROACH | |
| 4. DESCRIPTIVE NOTES (Type of report and inclusive dates)<br>Report 6 of a series; two volumes | |
| 5. AUTHOR(S) (Last name, first name, initial)<br>Rula, A. A.<br>Grabau, W. E.<br>Miles, R. D. | |
| 6. REPORT DATE<br>June 1963 | 7a. TOTAL NO. OF PAGES<br>342 — 7b. NO. OF REFS<br>31 |
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| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY<br>U. S. Army Materiel Command<br>Washington, D. C. 20315 |

13. ABSTRACT The study reported herein is part of a comprehensive effort, begun in 1949 to develop techniques for estimating the trafficability of soil by remote means. It is devoted specifically to development of techniques for analyzing and interpreting vertical aerial photographs for soil trafficability purposes. To provide a basis for this study, airphoto and soil trafficability data were collected over a period of several years by Purdue University and Waterways Experiment Station personnel from 33 humid-climate states and 2 arid-climate states in the United States. This report describes the principles and procedures of airphoto interpretation required to estimate the trafficability of soils, and summarizes data reported previously in supplemental reports in a form suitable for use by personnel engaged in airphoto-trafficability analysis. Soil factors, slope factors, and obstacle factors, all pertinent to terrain trafficability, are discussed. Terrain is classified into various representative landscapes which are fully described in regard to regional drainage, topography, local erosion, natural vegetation, cultural practices, parent material, soil profile, and trafficability and cross-country movement characteristics. Procedures for airphoto analysis of trafficability are rigidly defined, and an example of photo interpretation is given. Pertinent photographs, data tabulations, and appendices are presented in Volume II of this report. Appendix A lists the locations in which the soil and trafficability tests of this study were conducted. Appendix B presents a summary of the soil and site data obtained from these tests. Appendix C comprises nine generalized landscape-parent material maps, showing world-wide geographic occurrence of each representative landscape type.
KEYWORDS: Airphoto interpretation; Trafficability prediction

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| 3. REPORT TITLE FORECASTING TRAFFICABILITY OF SOILS; A PILOT STUDY OF SOILS SUBJECTED TO FREEZING AND THAWING | | |
| 4. DESCRIPTIVE NOTES (Type of report and inclusive dates) Report 7 of a series | | |
| 5. AUTHOR(S) (Last name, first name, initial) Knight, S. J.<br>Smith, M. H. | | |
| 6. REPORT DATE June 1964 | 7a. TOTAL NO. OF PAGES 71 | 7b. NO. OF REFS 78 |
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| 10. AVAILABILITY/LIMITATION NOTICES Approved for public release; distribution unlimited. | | |
| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY U. S. Army Materiel Command Washington , D. C. 20315 | |

13. ABSTRACT

Moisture content, density, and soil strength data were obtained from two test areas in Michigan which are subject to periods of freezing. Each area contained three plots with different vegetation cover: bare, herbaceous, or hardwood. Meteorological data from neighboring weather stations were recorded. Analysis of data showed that (a) the greater the vegetation density, the later the date of the first frost's appearance; (b) the greater the vegetation density and snow cover depth, the less the mean frost depth; (c) soil moisture content increased significantly as frost depth increased, and decreased when frost depth decreased; (d) soil density followed a trend opposite to that of moisture content; (e) soil strength increased radically when soil was frozen; and (f) soil strength was lowest during and immediately after the final thawing period of the season.

KEYWORDS: Freeze-thaw; Soils; Trafficability; Trafficability prediction

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**1. ORIGINATING ACTIVITY (Corporate author)**
U. S. Army Engineer Waterways Experiment Station
Vicksburg, Mississippi

**2a. REPORT SECURITY CLASSIFICATION**
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**3. REPORT TITLE**
FORECASTING TRAFFICABILITY OF SOILS: Report 8, VARIABILITY OF PHYSICAL PROPERTIES OF LOESS SOILS, WARREN COUNTY, MISSISSIPPI

**4. DESCRIPTIVE NOTES (Type of report and inclusive dates)**
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**5. AUTHOR(S) (First name, middle initial, last name)**

Charles A. Carlson
Alvin R. McDaniel


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**10. DISTRIBUTION STATEMENT**
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**11. SUPPLEMENTARY NOTES**

**12. SPONSORING MILITARY ACTIVITY**
U. S. Army Materiel Command
Washington, D. C. 20315

**13. ABSTRACT**

This study was to determine if the average of soil strength values obtained in a small area can be reliably applied to larger areas. Values of properties used in predicting soil strength and classifying soils were compared for areas differing in size. Six test sites in each of four loessial soil series were established, using series boundaries on soil survey maps to locate the sites. The series were Memphis and Loring in the uplands and Collins and Falaya in the bottomlands. Each site had five sampling rows; each row had four sampling positions. Plots of pedologically distinct soil series were identified from field examination within sites and were used as an additional subdivision of test areas. Soil strength and moisture content data were collected on four visits, other physical property data on one visit. The four series could not be distinguished by soil strength because the cone indexes (CI's) varied widely for any one series and the range of CI for each series was about the same. Soils of the 6- to 12-in. layer of the uplands differed from those of the bottomlands in clay content and plasticity, but not in strength. The poorly drained Henry series and alluvial-fill soils of the uplands, as identified in the field, had the lowest CI's. Certain plots exhibited consistently different CI's for each visit than did other plots in the same series, and certain rows in the same plot showed consistently different CI's. These differences could not be explained satisfactorily in terms of soil series, or soil properties commonly used in the Unified Soil Classification System and the U. S. Department of Agriculture textural classification. Appendix A. includes basic data for each site.



KEYWORDS: Loess; Soil property variations; Soil strength; Trafficability; Trafficability prediction; [Vicksburg, Mississippi]


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| 1. ORIGINATING ACTIVITY (Corporate author)<br>U. S. Army Engineer Waterways Experiment Station<br>Vicksburg, Miss. 39180 | 2a. REPORT SECURITY CLASSIFICATION<br>Unclassified<br>2b. GROUP |

3. REPORT TITLE

FORECASTING TRAFFICABILITY OF SOILS; WATER TABLE STUDY AT CROSSETT, ARKANSAS

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
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5. AUTHOR(S) (First name, middle initial, last name)

John R. Bassett
Marvin P. Meyer

| 6. REPORT DATE | 7a. TOTAL NO. OF PAGES | 7b. NO. OF REFS |
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| Conducted in cooperation with the U. S. Forest Service, U. S. Department of Agriculture. | U. S. Army Materiel Command<br>Washington, D. C. 20315 |

13. ABSTRACT

The purpose of the study was to determine and evaluate soil, site, and weather factors that affect high water tables, and to explore means by which an existing method for predicting soil-moisture content of the 0- to 6-in. and 6- to 12-in. layers could be modified to improve its accuracy when applied to soils with high water tables. Factors that significantly affected the initiation, duration, and periodicity of high water tables were precipitation, topographic position, depth to a relatively impermeable soil layer, slope of ground, rate of evapotranspiration, and, where applicable, stream or river stage. A scheme for predicting daily depths to water tables was incorporated in the soil-moisture prediction method, resulting in reasonably accurate predictions of soil moisture content and soil strength.

KEYWORDS: Soil moisture prediction; Trafficability prediction; Water table prediction; [Crossett, Arkansas]

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| 1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Mississippi | 2a. REPORT SECURITY CLASSIFICATION Unclassified<br>2b. GROUP |

3. REPORT TITLE

FORECASTING TRAFFICABILITY OF SOILS; RELATIONS OF STRENGTH TO OTHER PROPERTIES OF FINE-GRAINED SOILS AND SANDS WITH FINES

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

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5. AUTHOR(S) (First name, middle initial, last name)

John G. Collins

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| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY |
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| | U. S. Army Materiel Command Washington, D. C. |


13. ABSTRACT Attempts were made to establish relations between cone index, rating cone index, and remolding index (penetrometer strength measures commonly used in soil trafficability studies) and moisture content, soil separates contents, Atterberg limits, organic matter content, and dry density. Analyses were based on 6- to 12-in. soil layer data from 95 widely varying soils. In general, the approach followed in analyzing data was to (a) express the relation between a measure of strength and moisture content for each site with one standard equation form, (b) select coefficients that would define the strength-moisture relation for each site, and (c) relate the coefficients to soil properties. Results of the analyses indicate that usually (a) strength decreases with an increase in moisture for a given soil, (b) at a given strength level moisture content increases with a decrease in grain size or an increase in plasticity but is not associated with changes in organic matter content or dry density, (c) at a given moisture content changes in strength are associated primarily with changes in clay and/or sand contents when the U. S. Department of Agriculture soil separates are considered and with plastic and/or liquid limits when the Atterberg limits are considered, and (d) the predictive power of derived strength relations is poor even though the relations are significant (5% level). Appendixes are included in which the basic data and procedures used in obtaining the data are presented.



KEYWORDS: Fine grained soils; Soil property relations; Soil strength prediction; Trafficability prediction


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| 3. REPORT TITLE PROJECT TANK TRAP: A Field Evaluation of Nuclear Terrain Barriers | | |
| 4. DESCRIPTIVE NOTES (Type of report and inclusive dates) Final Report | | |
| 5. AUTHOR(S) (First name, middle initial, last name) Major Bernard C. Hughes, William L. Harrison, Roger Paul | | |
| 6. REPORT DATE June 1969 | 7a. TOTAL NO. OF PAGES 83 | 7b. NO. OF REFS - - - |
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| b. PROJECT NO. | | |
| c. | 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) AD 693 817 | |
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| 10. DISTRIBUTION STATEMENT Approved for public release; distribution unlimited. | | |
| 11. SUPPLEMENTARY NOTES N/A | 12. SPONSORING MILITARY ACTIVITY N/A | |

13. ABSTRACT

Project TANK TRAP was conducted to determine the capability of selected tactical vehicles to traverse craters typical of those which could be produced with Atomic Demolition Munitions (*ADM*). The vehicles included in the test program were the M-60 Tank, M-113 Armored Personnel Carrier, and an articulated two-unit general purpose vehicle called the POLECAT. Trafficability testing of these vehicles was performed in the SCOOTER crater, the JANGLE U crater, and Pre-SCHOONER BRAVO crater. The results of the research project indicate that: (1) craters formed in dry soil by the detonation of explosives at the surface or at very shallow depths of burst (down to approximately 20 $ft/kt^{1/3.4}$) do not present significant trafficability problems to tracked tactical vehicles; (2) craters formed at or near optimum depth of burst ( 160 $ft/kt^{1/3.4}$) in dry soil are a trafficability obstacle to tracked tactical vehicles; and, (3) craters formed in hard rock, such as basalt, cannot be negotiated by tracked tactical vehicles without major modification of the crater and/or assistance by heavy duty equipment, either mobile or fixed.

KEYWORDS: Craters; Military vehicles; Mobility; Obstacles; Trafficability; [M-60; M-113; POLECAT]

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3. REPORT TITLE

HANDBOOK - A TECHNIQUE FOR PREPARING DESERT TERRAIN ANALOGS

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

5. AUTHOR(S) (Last name, first name, initial)

Van Lopik, Jack R.; Kolb, Charles R.

| 6. REPORT DATE | 7a. TOTAL NO. OF PAGES | 7b. NO. OF REFS |
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| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY |
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13. ABSTRACT

Description of a semiquantitative technique whereby desert areas are mapped in terms of general terrain factors, geometry factors, ground factors, and vegetation. Degrees of analogy are established between a study area (Yuma Test Station) and other selected desert areas. A composite analog map is prepared by superimposing geometry, ground, and vegetation analog maps and stratifying the resulting combinations.

Maps, 2 appendices

KEYWORDS: Desert regions; Military bases; Terrain analogs; Terrain analysis; Terrain factor maps; [Yuma Test Station]

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3. REPORT TITLE
PROJECT OTTER ( OVERLAND TRAIN TERRAIN EVALUATION RESEARCH)
PRETEST REPORT

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

5. AUTHOR(S) (Last name, first name, initial)
Shamburger, John R.; Kolb, Charles R.

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| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY |

13. ABSTRACT A test of the performance of the Overland Train in desert environment was conducted in 1962 at the Yuma Test Station, Arizona (YTA), using a system of terrain analysis and evaluation based on plan-profile, slope occurrence, slope, relief, soil type, soil consistency, rock type, and vegetation. The terrain factors of many world deserts, including the desert at Yuma, have been mapped. Fourteen test courses were tentatively selected at YTA subsequent to a comprehensive office study of terrain factor maps. Reasonably severe routes were chosen to test the mobility of the Overland Train. Terrain factor data and aerial imagery of the course were obtained. Terrain types were classified according to the WES mapping system along nine of the courses.

Illustrations, tables, maps

KEYWORDS: Desert regions; Military bases; Off-road mobility; Terrain analysis; Terrain factor maps; Overland Train; [Project OTTER; Yuma Test Station]

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|---|---|
| 1. ORIGINATING ACTIVITY (Corporate author)<br>U. S. Army Engineer Waterways Experiment Station<br>P. O. Box 631<br>Vicksburg, Miss. | 2a. REPORT SECURITY CLASSIFICATION<br>Unclassified<br>2b. GROUP |

3. REPORT TITLE

PROJECT OTTER (OVERLAND TRAIN TERRAIN EVALUATION RESEARCH); TEST REPORT

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

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5. AUTHOR(S) (Last name, first name, initial)

Shamburger, John H., and Duke, Leiland M.

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| 8a. CONTRACT OR GRANT NO. | 9a. ORIGINATOR'S REPORT NUMBER(S) |
| b. PROJECT NO. 1-V-0-25001-A-131 | Technical Report No. 3-588, Report 2 |
| c. | 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) |
| d. | AD 613 166 |

10. AVAILABILITY/LIMITATION NOTICES

Approved for public release; distribution unlimited.

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| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY<br>Research and Development Directorate,<br>U. S. Army Materiel Command |

13. ABSTRACT A program designed to objectively test and quantitatively evaluate the cross-country mobility of the Overland Train (a logistical cargo carrier) in a desert environment was conducted over selected courses at the U. S. Army Yuma Proving Ground, Arizona, during February and June 1963. A semiquantitative system for terrain classification, developed at the U. S. Army Engineer Waterways Experiment Station (WES) and used to classify several world deserts in the Northern Hemisphere, was utilized to describe the terrain along the selected courses at Yuma. Sixteen courses were tentatively selected at Yuma; however, tests were terminated after only two courses had been traversed. The following data were collected for each test course: fuel consumption; electrical energy required to operate the driving, traction, and steering systems; distance traveled; dust density; and acceleration at specific points on the train. These data were compared with "base values" obtained during train operation on a level, paved road. Effects of terrain on cross-country operation were: decrease in speed, increase in path length, and increase in fuel consumption. These effects were attributed to microgeometric features and the direction of travel across these features. Quantitative relations between speed in miles per hour and fuel consumption in gallons per mile were established. Terrain types, classified according to the WES mapping system, along the two test courses are compared to the terrain of deserts of North Africa, the Middle East, and South Central Asia.

KEYWORDS: Desert regions; Military bases; Off-road mobility; Terrain analogs; Terrain analysis; Overland Train; [Project OTTER; Yuma Test Station]

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| 1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Miss. | 2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP |

3. REPORT TITLE

OPERATION SWAMP FOX I, TERRAIN AND SOIL TRAFFICABILITY OBSERVATIONS

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

5. AUTHOR(S) (Last name, first name, initial)

Schreiner, B. G.
Rula, A. A.

| 6. REPORT DATE | 7a. TOTAL NO. OF PAGES | 7b. NO. OF REFS |
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| August 1962 | 82 | 0 |

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| 8a. CONTRACT OR GRANT NO. b. PROJECT NO. 8S70-05-001 Trafficability and Mobility Research c. Subproject No. -02 Surface Mobility (Trafficability) d. | 9a. ORIGINATOR'S REPORT NUMBER(S) Technical Report No. 3-609 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) AD 290 529 |

10. AVAILABILITY/LIMITATION NOTICES

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| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY |
|---|---|
| See MP 4-556 for Swamp Fox II operation. | Chief of Engineers, DA Washington, D. C. 20315 |

13. ABSTRACT

In August-October 1961, the U. S. Army Transportation Corps conducted Operation Swamp Fox I, a 93-mile cross-country operation, in Panama. The Transportation Board formed the nucleus, command, and transportation agency for a combined technical services team of specialists. Waterways Experiment Station observers collected data on terrain, vegetation, and soils, and observed the effects of these factors on movement of twelve types of military, self-propelled, wheeled and tracked vehicles. They also tested instruments and techniques for determining trafficability of Panama soils. The data, collected under adverse conditions, are approximate and incomplete in many respects. Gullies, rivers, vegetation, wet surface-soil conditions, and particularly steep, frequent slopes were significant obstacles to vehicle movement. Difficult going necessitated dropping conventional wheeled vehicles early. The soils encountered were generally capable of supporting the vehicles used. The instruments and techniques used to determine soil trafficability appeared adequate. Further testing is recommended. An Appendix describes procedures for preparing vegetation structural diagrams.

KEYWORDS: Field tests; Military vehicles; Off-road mobility; Terrain analysis; Trafficability; Tropical regions; [Panama; Swamp Fox]

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| 1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station, P. O. Box 631, Vicksburg, Miss. | 2a. REPORT SECURITY CLASSIFICATION Unclassified<br>2b. GROUP |
| 3. REPORT TITLE A TECHNIQUE FOR MAPPING TERRAIN MICROGEOMETRY | |
| 4. DESCRIPTIVE NOTES (Type of report and inclusive dates) | |
| 5. AUTHOR(S) (Last name, first name, initial) Broughton, J. D.; Saucier, R. T. | |
| 6. REPORT DATE November 1962 | 7a. TOTAL NO. OF PAGES 69<br>7b. NO. OF REFS |
| 8a. CONTRACT OR GRANT NO.<br>b. PROJECT NO. 8S70-05-001-02<br>c.<br>d. | 9a. ORIGINATOR'S REPORT NUMBER(S) Technical Report No. 3-612<br>9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) AD 295 473 |
| 10. AVAILABILITY/LIMITATION NOTICES Approved for public release; distribution unlimited. | |
| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY |

13. ABSTRACT


A method of microgeometry classification to be used in cataloging soil-moisture prediction sites. Four parameters are utilized: overall slope, slope reversals, relief, and percentage increase of surface length over plan length. Measurement of the four factors results in a numerical array which is a semi-quantitative descriptor of the terrain.

Tables, two appendices


KEYWORDS: Microgeometry classification; Microgeometry mapping

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| 1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Miss. | 2a. REPORT SECURITY CLASSIFICATION Unclassified |
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3. REPORT TITLE

ENVIRONMENTAL FACTORS AFFECTING GROUND MOBILITY IN THAILAND, PRELIMINARY SURVEY

4. DESCRIPTIVE NOTES (Type of report and inclusive dates) Final report consisting of a main volume and eight appendices (A-H) in separate volumes.

5. AUTHOR(S) (Last name, first name, initial)

Rula, A. A. Orvedal, A. C. Ansted, G. W.
Grabau, W. E. Harden, H. W. Czako, T. F.

| 6. REPORT DATE | 7a. TOTAL NO. OF PAGES | 7b. NO. OF REFS |
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| May 1963 | 133 | 64 |

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| 8a. CONTRACT OR GRANT NO. | 9a. ORIGINATOR'S REPORT NUMBER(S) Technical Report No. 5-625, Main vol. & Appendicies A - H |
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| d. | |

10. AVAILABILITY/LIMITATION NOTICES

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| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY |
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| | Advanced Research Projects Agency Washington, D. C. 20315 |


13. ABSTRACT The study reported herein was a preliminary investigation made to provide guidance for a planned, longer range research program to develop and apply new and existing methods for measuring and predicting in quantitative and semiquantitative terms the effects of environmental factors on ground vehicles operating in Southeast Asia. The report is concerned specifically with the results of a field program conducted in Thailand. It presents a summary of the state of the art of measuring and predicting the effects of environmental factors on ground mobility, describes the environmental factors that affect ground mobility, presents the factor family concept and data adapted to ground-mobility purposes, and categorizes in tabular form environmental data by landscape types and subunits that occur in Thailand. Estimates of the probable effects of terrain factors on the performance of highly mobile vehicles are made for each landscape subunit. The report also presents conclusions and recommendations derived from an evaluation of the investigation. Eight appendices (A-H) were also published (in separate volumes) in conjunction with this report. Appendix A describes the results of a survey of unclassified existing data and literature. Appendices B, C, D, E, F, and G present methods of measurement and data tabulations and graphic presentations relative to the specific terrain factor with which each is concerned, i.e. soil classification, soil trafficability, vegetation, surface geometry, hydrologic geometry, and weather and climate, respectively. Appendix H presents an evaluation of the roads over which the preliminary survey test team traveled during the field data collection.



KEYWORDS: Environmental analysis; Environmental factors; Off-road mobility; Road tests (Vehicles); State-of-the-art studies; Terrain classification; Tropical regions; [Thailand]


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|---|---|
| 1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station, Corps of Engineers, Vicksburg, Miss. 39180 | 2a. REPORT SECURITY CLASSIFICATION Unclassified<br>2b. GROUP |

3. REPORT TITLE

ANALOGS OF YUMA TERRAIN IN NORTHEAST AFRICAN DESERT

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

5. AUTHOR(S) (Last name, first name, initial)

Dornbusch, William K, Jr.
et al.

| 6. REPORT DATE | 7a. TOTAL NO. OF PAGES | 7b. NO. OF REFS |
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| 8a. CONTRACT OR GRANT NO. | 9a. ORIGINATOR'S REPORT NUMBER(S) |
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| c. | 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) |
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10. AVAILABILITY/LIMITATION NOTICES

Approved for public release; distribution unlimited.

| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY |
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| | U. S. Army Materiel Command |

13. ABSTRACT To evaluate the adequacy of the Yuma Proving Ground as a test site representative of world desert conditions, the extent of occurrence of Yuma terrain types in the Northeast African (NEA) and other world desert areas must be determined. In order to make valid comparisons, a uniform system of describing, mapping, and comparing desert terrain must be employed. In this report both the Yuma and NEA deserts are mapped in terms of general or aggregate terrain, geometry, ground, and vegetation factors. General terrain factors include physiography, hypsometry, and landform-surface conditions. Geometry and ground factors are characteristic plan-profile, occurrence of slopes greater than 50 percent, characteristic slope, characteristic relief, soil type, soil consistency, and type of surface rock. Terrain-factor data are synthesized to establish the degree of analogy of a particular NEA area with selected portions of the Yuma Proving Ground. Ground and vegetation analog maps were prepared in similar fashion. A terrain-type analog map is prepared by superimposing the geometry, ground, and vegetation analog maps and stratifying the resulting combinations. Highly analogous NEA desert tracts exhibit or closely approximate combinations of terrain-factor mapping units found at Yuma, and the degree of analogy decreases directly as the similarity to such combinations decreases. The techniques used in preparing these maps permit comparison of terrain in areas mapped at different scales as well as in areas mapped at similar scales, enabling for the first time comparison of all the deserts of the Northern Hemisphere.

Maps, illustrations, tables.

KEYWORDS: Desert regions; Terrain analogs; Terrain analysis; Terrain factor maps; [Africa; Yuma, Arizona]

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| 1. ORIGINATING ACTIVITY (Corporate author)<br>U. S. Army Engineer Waterways Experiment Station<br>P. O. Box 631<br>Vicksburg, Miss. | 2a. REPORT SECURITY CLASSIFICATION<br>Unclassified<br>2b. GROUP |

3. REPORT TITLE

ANALOGS OF YUMA TERRAIN IN SOUTH CENTRAL ASIAN DESERT

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

5. AUTHOR(S) (Last name, first name, initial)

Dornbusch, William K., Jr.
et al.

| 6. REPORT DATE | 7a. TOTAL NO. OF PAGES | 7b. NO. OF REFS |
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| b. PROJECT NO. 1-T-0-25001-A-131 | Technical Report 3-630, Report 2 |
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10. AVAILABILITY/LIMITATION NOTICES

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| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY |
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| | U. S. Army Materiel Command |

13. ABSTRACT To evaluate the adequacy of the Yuma Proving Ground as a test site representative of world desert conditions, the extent of occurrence of Yuma terrain types in the South Central Asian (SCA) and other world desert areas must be determined. In order to make valid comparisons, a uniform system of describing, mapping, and comparing desert terrain must be employed. In this report both the Yuma and SCA deserts are mapped in terms of general or aggregate terrain, geometry, ground, and vegetation factors. General terrain factors include physiography, hypsometry, and landform-surface conditions. Geometry and ground factors are characteristic plan-profile, occurrence of slopes greater than 50 percent, characteristic slope, characteristic relief, soil type, soil consistency, and type of surface rock. Terrain-factor data are synthesized to establish the degree of analogy of a particular SCA area with selected portions of the Yuma Proving Ground. Ground and vegetation analog maps were prepared in similar fashion. A terrain-type analog map is prepared by superimposing the geometry, ground, and vegetation analog maps and stratifying the resulting combinations. Highly analogous SCA desert tracts exhibit or closely approximate combinations of terrain-factor mapping units found at Yuma, and the degree of analogy decreases directly as the similarity to such combinations decreases. The techniques used in preparing these maps permit comparison of terrain in areas mapped at different scales as well as in areas mapped at similar scales, enabling for the first time comparison of all the deserts of the Northern Hemisphere.
Maps, tables, illustrations

KEYWORDS: Desert regions; Terrain analogs; Terrain analysis; Terrain factor maps; [Asia; Yuma, Arizona]

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| 1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station, P. O. Box 631, Vicksburg, Mississippi | 2a. REPORT SECURITY CLASSIFICATION Unclassified; 2b. GROUP |
| 3. REPORT TITLE ANALOGS OF YUMA TERRAIN IN THE MEXICAN DESERT | |
| 4. DESCRIPTIVE NOTES (Type of report and inclusive dates) | |
| 5. AUTHOR(S) (Last name, first name, initial) Dornbusch, William K., Jr. et al. | |
| 6. REPORT DATE April 1959 | 7a. TOTAL NO. OF PAGES; 7b. NO. OF REFS |
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| c. | 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) AD 478 847 |
| d. | |
| 10. AVAILABILITY/LIMITATION NOTICES Approved for public release; distribution unlimited. | |
| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY U. S. Army Materiel Command |

13. ABSTRACT To evaluate the adequacy of the Yuma Proving Ground as a test site representative of world desert conditions, the extent of occurrence of Yuma terrain types in the Mexican and other world desert areas must be determined. In order to make valid comparisons, a uniform system of describing, mapping, and comparing desert terrain must be employed. In this report both the Yuma and Mexican deserts are mapped in terms of general or aggregate terrain, geometry, hypsometry, and landform-surface conditions. Geometry and ground factors are characteristic plan-profile, occurrence of slopes greater than 50 percent, characteristic slope, characteristic relief, soil type, soil consistency, and type of surface rock. Terrain-factor data are synthesized to establish the degree of analogy of a particular Mexican area with selected portions of the Yuma Proving Ground. Ground and vegetation analog maps were prepared in similar fashion. A terrain-type analog map is prepared by superimposing the geometry, ground, and vegetation analog maps and stratifying the resulting combinations. Highly analogous Mexican desert tracts exhibit or closely approximate combinations of terrain-factor mapping units found at Yuma, and the degree of analogy decreases directly as the similarity to such combinations decreases. The techniques used in preparing these maps permit comparison of terrain in areas mapped at different scales as well as in areas mapped at similar scales, enabling for the first time comparison of all the deserts of the Northern Hemisphere.
Maps, tables, illustrations

KEYWORDS: Desert regions; Terrain analogs; Terrain analysis; Terrain factor maps; [Mexico; Yuma, Arizona]

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| 1. ORIGINATING ACTIVITY (Corporate author)<br>U. S. Army Engineer Waterways Experiment Station<br>P. O. Box 631<br>Vicksburg, Mississippi | 2a. REPORT SECURITY CLASSIFICATION<br>Unclassified<br>2b. GROUP |

3. REPORT TITLE

ANALOGS OF YUMA TERRAIN IN THE MIDDLE EASTERN DESERT

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

In one volume (June 1960). In 2 Vols: Vol I, Text; Vol II, Plates (June 1966).

5. AUTHOR(S) (Last name, first name, initial)

Dornbusch, William K, Jr.
Van Lopik, Jack R.
Kolb, Charles, R.

| 6. REPORT DATE | 7a. TOTAL NO. OF PAGES | 7b. NO. OF REFS |
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| June 1960, Revised June 1966 | Vol I 55 Vol II 30 | |

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10. AVAILABILITY/LIMITATION NOTICES

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| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY |
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| | U. S. Army Materiel Command |

13. ABSTRACT To evaluate the adequacy of the Yuma Proving Ground as a test site representative of world desert conditions, the extent of occurrence of Yuma terrain types in the Middle Eastern and other world desert areas must be determined. In order to make valid comparisons, a uniform system of describing, mapping, and comparing desert terrain must be employed. In this report both the Yuma and Middle Eastern deserts are mapped in terms of general or aggregate terrain, geometry, ground, and vegetation factors. General terrain factors include physiography, hypsometry, and landform-surface conditions. Geometry and ground factors are characteristic plan-profile, occurrence of slopes greater than 50 percent, characteristic slope, characteristic relief, soil type, soil consistency, and type of surface rock. Terrain-factor data are synthesized to establish the degree of analogy of a particular Middle Eastern area with selected portions of the Yuma Proving Ground. Ground and vegetation analog maps were prepared in similar fashion. A terrain-type analog map is prepared by superimposing the geometry, ground, and vegetation analog maps and stratifying the resulting combinations. Highly analogous Middle Eastern desert tracts exhibit or closely approximate combinations of terrain-factor mapping units found at Yuma, and the degree of analogy decreases directly as the similarity to such combinations decreases. The techniques used in preparing these maps permit comparison of terrain in areas mapped at different scales as well as in areas mapped at similar scales, enabling for the first time comparison of all the deserts of the Northern Hemisphere.
Maps, illustrations, tables

KEYWORDS: Desert regions; Terrain analogs; Terrain analysis; Terrain factor maps; [Middle East; Yuma, Arizona]

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| 1. ORIGINATING ACTIVITY (Corporate author)<br>U. S. Army Engineer Waterways Experiment Station<br>P. O. Box 631<br>Vicksburg, Miss. 39180 | 2a. REPORT SECURITY CLASSIFICATION<br>Unclassified<br>2b. GROUP |

3. REPORT TITLE

ANALOGS OF YUMA TERRAIN IN THE SOUTHWEST UNITED STATES

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

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5. AUTHOR(S) (First name, middle initial, last name)

Kolb, Charles R.
VanLopik, Jack R.

| 6. REPORT DATE | 7a. TOTAL NO. OF PAGES | 7b. NO. OF REFS |
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| b. PROJECT NO. I-T-0-25001-A-131 | Technical Report 3-630, Report 5, Vols 1-2 |
| c. | 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) |
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| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY |
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| | U. S. Army Materiel Command |

13. ABSTRACT

To evaluate the adequacy and suitability of the Yuma Test Station as a test site representative of world desert conditions, it was necessary to determine to what extent Yuma terrain types occur in the Southwest United States (SWUS) desert and other world deserts. For valid comparisons, a uniform system of describing, mapping, and comparing desert terrain is necessary. In vol II of this report, both the Yuma Test Station and the SWUS desert are mapped in terms of general geometry, ground, and vegetation factors. The data mapped for each terrain factor in each desert area were then synthesized to establish the degree of analog of a particular SWUS area with selected portions of the Yuma area. Final terrain-type analog maps were prepared by superimposing the geometry, ground, and vegetation analog maps and stratifying the resulting combinations. Highly analogous SWUS desert tracts exhibit combinations of terrain-factor mapping units found at Yuma, and the degree of analogy decreases as the similarity to such combinations decreases. Vol I of the report summarizes the analogy, and describes and discusses the factors used and the mapping technique. Appendix A is a general discussion of the philosophy and problems associated with terrain analysis and comparison.

KEYWORDS: Desert regions; Terrain analogs; Terrain analysis; Terrain factor maps; [Southwest United States; Yuma, Arizona]

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| 1. ORIGINATING ACTIVITY (Corporate author)<br>U. S. Army Engineer Waterways Experiment Station<br>P. O. Box 631<br>Vicksburg, Miss. | 2a. REPORT SECURITY CLASSIFICATION<br>Unclassified<br>2b. GROUP |

3. REPORT TITLE

ANALOGS OF YUMA TERRAIN IN THE NORTHWEST AFRICAN DESERT

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Technical Report (in 2 Vols: I text; II plates).

5. AUTHOR(S) (Last name, first name, initial)

Van Lopik, Jack R.
Kolb, Charles R.
Shamburger, John H.

| 6. REPORT DATE | 7a. TOTAL NO. OF PAGES | 7b. NO. OF REFS |
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| 8a. CONTRACT OR GRANT NO. | 9a. ORIGINATOR'S REPORT NUMBER(S) |
| b. PROJECT NO. 1-T-0-25001-A-131 | Technical Report 3-630, Report 6, Vols 1-2 |
| c. | 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) |
| d. | AD 466 206 (Vol 1); AD 466 207 (Vol 2) |

10. AVAILABILITY/LIMITATION NOTICES

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| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY |
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| | U. S. Army Materiel Command |

13. ABSTRACT To evaluate the adequacy of the Yuma Proving Ground as a test site representative of world desert conditions, the extent of occurrence of Yuma terrain types in the Northwest African (NWA) and other world desert areas must be determined. In order to make valid comparisons, a uniform system of describing, mapping, and comparing desert terrain must be employed. In this report both the Yuma and NWA deserts are mapped in terms of general or aggregate terrain, geometry, ground, and vegetation factors. General terrain factors include physiography, hypsometry, and landform-surface conditions. Geometry and ground factors are characteristic plan-profile, occurrence of slopes greater than 50 percent, characteristic slope, characteristic relief, soil type, soil consistency, and type of surface rock. Terrain-factor data are synthesized to establish the degree of analogy of a particular NWA area with selected portions of the Yuma Proving Ground. Ground and vegetation analog maps were prepared in similar fashion. A terrain-type analog map is prepared by superimposing the geometry, ground, and vegetation analog maps and stratifying the resulting combinations. Highly analogous NWA desert tracts exhibit or closely approximate combinations of terrain-factor mapping units found at Yuma, and the degree of analogy decreases directly as the similarity to such combinations decreases. The techniques used in preparing these maps permit comparison of terrain in areas mapped at different scales as well as in areas mapped at similar scales, enabling for the first time comparison of all the deserts of the Northern Hemisphere.
Tables, illustrations, maps

KEYWORDS: Desert regions; Terrain analogs; Terrain analysis; Terrain factor maps; [Africa; Yuma, Arizona]

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| 1. ORIGINATING ACTIVITY (Corporate author)<br>U. S. Army Engineer Waterways Experiment Station<br>Vicksburg, Mississippi | 2a. REPORT SECURITY CLASSIFICATION<br>Unclassified<br>2b. GROUP |

3. REPORT TITLE

MOBILITY ENVIRONMENTAL RESEARCH STUDY; A LITERATURE SURVEY OF ENVIRONMENTAL FACTORS IN THAILAND

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Report 1 of series

5. AUTHOR(S) (Last name, first name, initial)

Broughton, Jerald D.
Shamburger, John H.
Del Mar, David B.

| 6. REPORT DATE | 7a. TOTAL NO. OF PAGES | 7b. NO. OF REFS |
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| June 1965 | 336 | 1613 |

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| b. PROJECT NO. | Technical Report No. 3-681, Report 1 |
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10. AVAILABILITY/LIMITATION NOTICES

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13. ABSTRACT


The survey reported herein was a search for maps, written text or descriptions and aerial photographs that would be useful in quantitatively describing the physical attributes of the environment found in Thailand that affect ground mobility. These physical attributes include surface geometry, soils, vegetation, hydrologic geometry, and climate. Sections corresponding to the physical attributes and a general section were established for filing and cross-filing references according to their data content. Each section was further subdivided into two subsections, text and map references.

A list of 1613 unclassified references was compiled, and the contents of each reference were evaluated according to the following categories: (a) quantitative data, (b) qualitative data, (c) useful data absent, (d) gazetteers, bibliographies, etc., and (e) not reviewed. Of these references, 1012 were reviewed and annotated, 484 were cross-filed, and 117 were not reviewed. Geographic index maps were prepared to show specific areas of Thailand described in the annotated references when these areas were less than the entire country. Each bibliographic entry is identified by a series of symbols indicating (a) section and reference number, (b) subsection (text, maps, or both), (c) evaluation category, and (d) if and where cross-filed.



KEYWORDS: Bibliographies; Environmental analysis; Environmental factors; Mobility; State-of-the-art studies; Tropical regions; [Thailand]


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3. REPORT TITLE

TERRAIN ANALYSIS BY ELECTROMAGNETIC MEANS; LABORATORY INVESTIGATIONS IN THE 0.76- TO 5.00-MICRON SPECTRAL REGION

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Report 1 of a series

5. AUTHOR(S) (Last name, first name, initial)

Davis, B. R.
Lipscomb, E. B.
Knight, S. J.

| 6. REPORT DATE | 7a. TOTAL NO. OF PAGES | 7b. NO. OF REFS |
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| October 1965 | 165 | 0 |

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| 8a. CONTRACT OR GRANT NO.<br>b. PROJECT NO. 1-V-0-21701-A-046,<br>Trafficability and Mobility Research<br>c. Task -04, Mobility Terrain Analysis and Symbology<br>d. | 9a. ORIGINATOR'S REPORT NUMBER(S)<br>Technical Report No. 3-693<br>Report No. 1<br>9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)<br>AD 472 873 |

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| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY |
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| | U. S. Army Materiel Command<br>Washington, D. C. 20315 |

13. ABSTRACT

This report presents the results of tests conducted to determine the capabilities of active electromagnetic sensors operating in the 0.76- to 5.00-micron spectral region to measure terrain characteristics affecting trafficability of soils. Controlled tests were conducted under laboratory conditions in an attempt to correlate the effects of soil composition, moisture content, and density with the quantity of infrared energy reflected from a soil sample. Results of the tests indicate that the composition and moisture content of homogeneous soil specimens can be characterized by active infrared sensors under controlled laboratory conditions. However, since infrared energy is reflected by infinitesimally thin surfaces of materials, information concerning density and subsurface parameters cannot be discerned. Techniques for prediction of soil parameters through the use of multiwavelength analysis are discussed.

KEYWORDS: Infrared rays; Laboratory tests; Remote sensing; Soils; Trafficability

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3. REPORT TITLE

TERRAIN ANALYSIS BY ELECTROMAGNETIC MEANS; RADAR RESPONSES TO LABORATORY PREPARED SOIL SAMPLES

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Report 2 of a series

5. AUTHOR(S) (Last name, first name, initial)

Lundien, Jerry R.

| 6. REPORT DATE | 7a. TOTAL NO. OF PAGES | 7b. NO. OF REFS |
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| September 1966 | 99 | 12 |

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| 8a. CONTRACT OR GRANT NO.<br>NASA Defense Purchase Request No.<br>b. PROJECT NO.<br>R-25-04-001<br>c.<br>d. | 9a. ORIGINATOR'S REPORT NUMBER(S)<br>Technical Report No. 3-693<br>Report 2<br>9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)<br>AD 802 104 |

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| Service Agency:<br>U. S. Army Materiel Command<br>Washington, D. C. | National Aeronautics and Space Administration, Washington, D. C. |

13. ABSTRACT Laboratory tests were conducted with radar sensors to detect the presence of and measure the depth to subsurface interfaces when the surface was bare, and to determine the influence of vegetation at various stages of growth on radar responses. A secondary purpose was to continue earlier studies to relate radar returns and the electrical constants that they provided to moisture content and density of samples. Large laboratory samples were prepared at various moisture contents and densities and with various depths to a subsurface metal plate. Standard pulsed radar sensors operating with frequencies of 297, 5870, 9375, and 34,543 megacycles/sec and directed at various angles of incidence to the surface were employed. The results of this laboratory study indicate that the standard pulsed radar sensors can provide information that will permit an estimate of the moisture content of deep, homogeneous soil samples and the detection of surface vegetation of various heights. Radar signatures of vegetation-covered soil were more significantly altered at Ka-, X-, and C-band frequencies than at P-band frequencies. However, standard pulsed radar sensors used monochromatically cannot provide information for predicting depth to subsurface interfaces or for directly indicating the presence of a subsurface interface. The systematic manner in which soil depths were varied in this study permitted an analytical solution to the problem of measuring depths of layers and led to the conclusion that properly designed radar systems could measure depths to subsurface interfaces. Three such systems are proposed.

KEYWORDS: Laboratory tests; Radar; Remote sensing; Soils; Trafficability

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| 1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Miss. 39180 | 2a. REPORT SECURITY CLASSIFICATION Unclassified |
| | 2b. GROUP |

3. REPORT TITLE
TERRAIN ANALYSIS BY ELECTROMAGNETIC MEANS: Report 3, LABORATORY INVESTIGATIONS IN THE 0- TO 2.82-MEV GAMMA-RAY SPECTRAL REGION

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
Report 3 of a series

5. AUTHOR(S) (First name, middle initial, last name)
Jerry R. Lundien

| 6. REPORT DATE | 7a. TOTAL NO. OF PAGES | 7b. NO. OF REFS |
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| November 1967 | 128 | 8 |

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| 8a. CONTRACT OR GRANT NO. | 9a. ORIGINATOR'S REPORT NUMBER(S) Technical Report No. 3-693, Report No. 3 |
| b. PROJECT NO. 1-V-0-14501-B52A, Research in Earth Sciences, Task -01, Earth Sciences c.(Terrain Analysis), Project No. 1-V-0-21701-A-046, Trafficability and Mobility d.Research, Task -04, Mobility Terrain Analysis and Symbology | 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) AD 825 172 |

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| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY |
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| | U. S. Army Materiel Command Washington, D. C. 20315 |

13. ABSTRACT

Gamma-ray spectra over the energy range 0 to 2.82 mev were obtained from samples of sand, silt, and clay. All tests were conducted in the laboratory in a specially designed low-background enclosure. Data were analyzed by considering both photopeak energy level and radioactive source content in relation to soil parameters.

The results indicate that the thorium, uranium, and potassium photopeak counts are proportional to moisture content expressed as a percentage of dry soil weight. When expressed as ratios to one another, the photopeaks lose nearly all moisture content information but appear to be related to each of the three selected specific soil types.

Appendixes A and B present a listing of the FORTRAN computer program and a discussion of the data reduction techniques that it uses in the analysis of gamma-ray spectral data.

KEYWORDS: Gamma rays; Laboratory tests; Remote sensing; Soils; Trafficability

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| 1. ORIGINATING ACTIVITY (Corporate author)<br>U. S. Army Engineer Waterways Experiment Station<br>Vicksburg, Miss. | 2a. REPORT SECURITY CLASSIFICATION<br>Unclassified<br>2b. GROUP |

3. REPORT TITLE

TERRAIN ANALYSIS BY ELECTROMAGNETIC MEANS: REPORT 4; LABORATORY INVESTIGATIONS OF THE INFRARED EMISSIVITY OF SOILS BELOW A WAVELENGTH OF 7.7 MICRONS

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Report 4 of a series

5. AUTHOR(S) (First name, middle initial, last name)

Lavecchia, Nicholas J., Jr.
Williamson, Albert N., Jr.
Nikodem, Hans J.

| 6. REPORT DATE | 7a. TOTAL NO. OF PAGES | 7b. NO. OF REFS |
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| May 1967 | 61 | 7 |

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| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY<br>U. S. Army Materiel Command<br>Washington, D. C. 20315 |

13. ABSTRACT

This report presents the results of tests using a passive infrared scanning system responsive to radiation below approximately 7.7 microns to determine if a correlation could be found between the infrared emissivity of soils and their trafficability parameters. It was established that a relation between the passive emission of soils and soil surface moisture content can be measured, but contributing factors other than soil emissivity were encountered. These factors were soil surface temperature and incident radiation on the soil surface. These factors so influenced the magnitude of the net detected energy that this measurement is meaningless, in terms of soil emissivity, unless the contribution of the other factors is known. Progressive modifications in measuring techniques were made in an attempt to isolate these components. The data indicate that the information that can be obtained from a passive infrared sensor using the technique derived herein is not sufficient to determine emissivity values of terrain with sufficient accuracy for practical application.

KEYWORDS: Infrared rays; Laboratory tests; Remote sensing; Soils; Trafficability

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**1. ORIGINATING ACTIVITY (Corporate author)**
U. S. Army Engineer Waterways Experiment Station
Vicksburg, Mississippi

**2a. REPORT SECURITY CLASSIFICATION**
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**2b. GROUP**

**3. REPORT TITLE**
TERRAIN ANALYSIS BY ELECTROMAGNETIC MEANS; Report 5, LABORATORY MEASUREMENT OF ELECTROMAGNETIC PROPAGATION CONSTANTS IN THE 1.0- to 1.5-GHz MICROWAVE SPECTRAL REGION

**4. DESCRIPTIVE NOTES (Type of report and inclusive dates)**
Report 5 of a series

**5. AUTHOR(S) (First name, middle initial, last name)**
Jerry R. Lundien

| 6. REPORT DATE | 7a. TOTAL NO. OF PAGES | 7b. NO. OF REFS |
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**9a. ORIGINATOR'S REPORT NUMBER(S)**
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**9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)**
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**10. DISTRIBUTION STATEMENT**
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**11. SUPPLEMENTARY NOTES**

**12. SPONSORING MILITARY ACTIVITY**
U. S. Army Materiel Command
Washington, D. C.

**13. ABSTRACT**
This investigation was made to (a) measure the basic electrical properties of various test samples at frequencies ranging from 1.074 to 1.499 GHz with an L-band interferometer and (b) to relate these basic electrical properties to the physical properties of the test samples. Twelve soils, described in Appendix A, were used in the test program. Laboratory tests on soil samples at various moisture contents and densities indicate a strong, nearly linear relation between the volumetric water content and relative dielectric constant. This relation is not greatly affected by changes in soil density, soil type, or small changes in frequency. Similar relations also exist between loss tangent and electrical conductivity and volumetric water content as modified by frequency, and may be useful for soil type identification. Tests were also run on samples of water and a sample of concrete. Results from the water samples show a decrease in the relative dielectric constant, loss tangent, and electrical conductivity with increasing temperature. The decrease in relative dielectric constant appears to be uniform with temperature from 0 to 65 C and is slightly less than 1/2 percent/C. This ratio may prove useful in estimating the effects of temperature change on the electrical properties of a soil-water mixture. Dielectric constant measurements are shown to be a sensitive measure of water loss in a concrete sample. In addition to the L-band interferometer, two other dielectric constant measurement devices are described in Appendixes B and C and the results of tests with these devices are presented. These are (a) a capacitor measuring system operating between 1 and 75 MHz for soil and water samples and (b) an open wire line (OWL) probe operating between 1 and 2 GHz for soil and concrete samples. KEYWORDS: Concrete samples; Laboratory tests; Microwaves; Remote sensing; Soils; Trafficability

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| | 2b. GROUP |

3. REPORT TITLE

CHARACTERISTICS OF U.S. RICE FIELDS AND THEIR EFFECTS ON GROUND MOBILITY

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

5. AUTHOR(S) (Last name, first name, initial)

Kennedy, J. G.
Rush, E. S.

| 6. REPORT DATE | 7a. TOTAL NO. OF PAGES | 7b. NO. OF REFS |
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| b. PROJECT NO. | Technical Report No. 3-702 |
| c. ARPA order No. 400 | 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) |
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| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY |
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| Service Agent: U. S. Army Materiel Command Washington, D. C. 20315 | Advanced Research Projects Agency Washington, D. C. 20315 |

13. ABSTRACT

The primary objective of this study was to obtain information on the environmental characteristics of rice fields in the United States and the effect of these characteristics on ground mobility for comparison with similar characteristics of rice fields in Southeast Asia. Twenty-two study sites were located in rice fields in a variety of soil types and under various cultural practices in Arkansas and Louisiana. Fifteen of these sites were selected to be visited for data collection several times during a one-year period. Data collected were soil moisture, soil strength, vegetation characteristics, surface geometry, hydrologic geometry, cultural practices, and weather. General conclusions were: (a) for most sites a good correlation exists between soil strength and soil-moisture content; (b) estimates of soil strength can be made by employing the WES soil moisture strength prediction method; (c) surface geometry features of U. S. rice fields would not be a significant deterrent to ground vehicles; (d) the soil strength in the fields tested is adequate to support at least one pass of most military vehicles; and (e) most hydrologic geometry features in U. S. and Southeast Asian rice fields are insurmountable for present standard military vehicles.

KEYWORDS: Environmental analysis; Environmental factors; Rice fields; Temperate regions; Terrain analogs; Trafficability; Tropical regions; [Thailand, Miss. River floodplain]

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3. REPORT TITLE

MOBILITY ENVIRONMENTAL RESEARCH STUDY; A QUANTITATIVE METHOD FOR DESCRIBING TERRAIN FOR GROUND MOBILITY; SUMMARY

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Volume I of an eight-volume report

5. AUTHOR(S) (First name, middle initial, last name)

John H. Shamburger
Warren E. Grabau

| 6. REPORT DATE | 7a. TOTAL NO. OF PAGES | 7b. NO. OF REFS |
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| May 1968 | 50 | 3 |

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| b. PROJECT NO. | Technical Report No. 3-726<br>Volume I |
| c. Order No. 400 | 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) |
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10. DISTRIBUTION STATEMENT

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| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY |
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| | Advanced Research Projects Agency<br>Service Agency; U. S. Army Materiel<br>Command, Washington, D. C. |

13. ABSTRACT

Terrain factors that significatly affect the locomotion of ground-contact vehicles are encompassed in four factor families--surface composition, surface geometry, vegetation, and hydrologic geometry. Since a condition of this study was to establish the effects of terrain on vehicle locomotion in Southeast Asia, six areas in Thailand were selected for detailed study. These areas are in the vicinities of Nakhon Sawan, Lop Buri, Chiang Mai, Pran Buri, Khon Kaen, and Chanthaburi. This report is presented in eight volumes. This volume is a summary and discusses in general terms the procedures that were used to acquire the necessary quantitative terrain information and the techniques that were employed to adapt these data to displays that meet the specific requirements of cross-country locomotion analysis. Data collection, reduction and analysis procedures, and techniques for mapping the specific factors of each factor family are presented in Volume II (Surface Composition), Volume III (Surface Geometry), Volume IV (Vegetation), and Volume V (Hydrologic Geometry). Data summaries are included as appendixes to the appropriate volumes. Air-photo interpretation techniques used to identify air-photo patterns of terrain features are presented in Volume VI. The method used to synthesize the factor-family maps into factor-complex maps for mobility purposes is presented in Volume VII. Map sets for each of the four factor families for the six study areas are presented in Volume VIII.

KEYWORDS: Mobility; Terrain analysis; Terrain classification; Terrain factor maps; Tropical regions; [Thailand]

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3. REPORT TITLE

MOBILITY ENVIRONMENTAL RESEARCH STUDY; A QUANTITATIVE METHOD FOR DESCRIBING TERRAIN FOR GROUND MOBILITY; SURFACE COMPOSITION

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

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5. AUTHOR(S) (First name, middle initial, last name)

Robert C. Wright
James R. Burns

| 6. REPORT DATE | 7a. TOTAL NO. OF PAGES | 7b. NO. OF REFS |
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| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY<br>Advanced Research Projects Agency;<br>Service Agency; U. S. Army Materiel<br>Command, Washington, D. C. |

13. ABSTRACT

This volume presents the methods used to collect, tabulate, and analyze basic data on surface composition of six selected Thailand study areas--Nakhon Sawan, Lop Buri, Chiang Mai, Pran Buri, Khon Kaen, and Chanthaburi. Fifteen mapping classes that expressed the different soil mass strength and soil surface strength conditions were established. The criteria used in isolating these classes were (a) that each class be identifiable using air-photo interpretation techniques and (b) that each class exhibit similar variations in strength with moisture content. Areas with equivalent trafficability characteristics in terms of the 15 map classes were delineated on 25 surface composition maps together covering the six study areas. This delineation was accomplished through interpretation of maps and air photos with control data in the form of field and laboratory information. The maps are presented in Volume VIII of this report. A compromise between the desired degree of mapping class refinement and that dictated by the photo-interpretation criteria was necessary because of the nature of the field data. During the mapping program when sample site data were extrapolated to unsampled areas, the degree of mapping refinement was of necessity only fair to low. It is recommended that additional studies be conducted on the use of air-photo identification techniques in classifying soil strength conditions. This approach is believed to be basically sound; however, more field verification of predicted values will help to determine the reliability of this approach.

KEYWORDS: Airphoto interpretation; Mobility; Surface composition factors; Surface composition mapping; Terrain analysis; Tropical regions; [Thailand]

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3. REPORT TITLE

MOBILITY ENVIRONMENTAL RESEARCH STUDY: A QUANTITATIVE METHOD FOR DESCRIBING TERRAIN FOR GROUND MOBILITY; SURFACE GEOMETRY

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Volume III of an eight-volume report

5. AUTHOR(S) (First name, middle initial, last name)

William K. Dornbusch, Jr.

| 6. REPORT DATE | 7a. TOTAL NO. OF PAGES | 7b. NO. OF REFS |
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| September 1967 | 214 | 5 |

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| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY |
| Service Agent: U. S. Army Materiel Command, Washington, D. C. | Advanced Research Projects Agency, Washington, D. C. |

13. ABSTRACT

This volume presents the methods used to collect, tabulate, and analyze basic data on the surface geometry of selected areas in Thailand. The descriptions of surface geometry features are so designed that the descriptive values can be used directly as input to an analytical model for predicting the cross-country speed of selected military vehicles. A method for classifying, interpreting, and mapping surface geometry factors from aerial photographs (air photos) was developed. Utilizing the field data collected and the air-photo interpretation methods developed, 25 surface geometry factor-family maps were prepared, together covering six selected study areas (Nakhon Sawan, Lop Buri, Chiang Mai, Pran Buri, Khon Kaen, and Chanthaburi). These mpas are presented in Volume VIII of this report. Air-photo interpretation methods for predicting and mapping surface geometry factors were largely successful. However, the degree of accuracy achieved for each of these factors varied considerably, being a function of the scale, quality, and vintage of the existing photography. It is recommended that studies be continued to develop air-photo interpretation techniques to improve the reliability of estimation of surface geometry factor values.

KEYWORDS: Airphoto interpretation; Mobility; Surface geometry factors; Surface geometry mapping; Terrain analysis; Tropical regions; [Thailand]

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| 3. REPORT TITLE<br>MOBILITY ENVIRONMENTAL RESEARCH STUDY; A QUANTITATIVE METHOD FOR DESCRIBING TERRAIN FOR GROUND MOBILITY; VEGETATION | | |
| 4. DESCRIPTIVE NOTES (Type of report and inclusive dates)<br>Volume IV of an eight-volume report | | |
| 5. AUTHOR(S) (First name, middle initial, last name)<br>Jerald D. Broughton<br>Eugene Addor | | |
| 6. REPORT DATE<br>March 1968 | 7a. TOTAL NO. OF PAGES<br>151 | 7b. NO. OF REFS<br>7 |
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| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY<br>Advanced Research Projects Agency;<br>Service Agency: U. S. Army Materiel Command, Washington, D. C. | |

13. ABSTRACT


Vegetation characteristics were measured according to established sampling procedures at 295 sites within six areas of Thailand. From these samples, stem diameter and spacing data were extracted for analysis, since these are the factors that significantly affect performance of ground-contact vehicles. A dual classification system was devised for mapping these factors in which spacing values of 0-1.5 m, >1.5-3.0 m, >3.0-9.0 m, and >9.0 m were determined for stem diameters of 5 cm or less, 13 cm or less, 23 cm or less, and 130 cm or less, and stem diameters of 3 cm or more, 8 cm or more, 15 cm or more, and 25 cm or more. Map units were identified and delimited on aerial photographs by established photo-interpretation keys and techniques. Twenty-five 1:50,000-scale map sheets were prepared for the six study areas, on which 72 distinct mapping classes were identified. The vegetation field data for the six study areas are summarized in Appendix A.



KEYWORDS: Airphoto interpretation; Mobility; Terrain analysis; Tropical regions; Vegetation factors; Vegetation mapping; [Thailand]


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| 1. ORIGINATING ACTIVITY (Corporate author)<br>U.S. Army Engineer Waterways Experiment Station<br>Vicksburg, Mississippi | 2a. REPORT SECURITY CLASSIFICATION<br>Unclassified<br>2b. GROUP |

3. REPORT TITLE

MOBILITY ENVIRONMENTAL RESEARCH STUDY: A QUANTITATIVE METHOD FOR DESCRIBING TERRAIN FOR GROUND MOBILITY; HYDROLOGIC GEOMETRY

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Volume V of report

5. AUTHOR(S) (First name, middle initial, last name)

Edgar E. Garrett
John H. Shamburger

| 6. REPORT DATE | 7a. TOTAL NO. OF PAGES | 7b. NO. OF REFS |
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| November 1967 | 103 | 7 |

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| 8a. CONTRACT OR GRANT NO.<br>b. PROJECT NO.<br>c. Order No. 400<br>d. | 9a. ORIGINATOR'S REPORT NUMBER(S)<br>Technical Report No. 3-726<br>Volume V<br>9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)<br>AD 827 290 |

10. DISTRIBUTION STATEMENT

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| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY<br>Advanced Research Projects Agency; Service Agency: U. S. Army Materiel Command, Washington, D. C. |

13. ABSTRACT

This volume presents the methods used in collecting hydrologic geometry data in selected areas in Thailand. The selection, analysis, and classification of parameters significant to vehicle mobility are discussed. The photo-interpretation methods used in identifying hydrologic geometry features from aerial photographs (air photos) and the extrapolation of these identifications to areas not investigated on the ground are presented. The rationale for cartographic portrayal of these parameters is explained. Utilizing the collected field data, available air photos, and the Army Map Service series of topographic maps, hydrologic geometry factor maps were prepared covering the six selected study areas (Nakhon Sawan, Lop Buri, Chiang Mai, Chanthaburi, Pran Buri, and Khon Kaen). The maps are presented in Volume VIII of this series. It proved only partially possible to determine the existence and value of the chosen parameters from air photos since some of the individual factors are wholly or partially below the water surface. Nevertheless, photo interpretation plus extrapolation from measured sites made it possible to map the parametric values by class range with reasonable validity. Recommendations are made involving improvement in data-collection techniques.

KEYWORDS: Airphoto interpretation; Hydrologic geometry factors; Hydrologic geometry mapping; Mobility; Terrain analysis; Tropical regions; [Thailand]

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| 1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire | 2a. REPORT SECURITY CLASSIFICATION Unclassified | |
| | 2b. GROUP | |
| 3. REPORT TITLE MOBILITY ENVIRONMENTAL RESEARCH STUDY; A QUANTITATIVE METHOD FOR EVALUATING TERRAIN FOR GROUND MOBILITY; SELECTED AIR-PHOTO PATTERNS OF TERRAIN FEATURES | | |
| 4. DESCRIPTIVE NOTES (Type of report and inclusive dates) Volume VI of report | | |
| 5. AUTHOR(S) (Last name, first name, initial) Frost, Robert E., Johnson, Philip L., Leighty, Robert D., Anderson, Vernon H., Poulin, Ambrose O., and Rinker, Jack N. | | |
| 6. REPORT DATE May 1966 | 7a. TOTAL NO. OF PAGES 327 | 7b. NO. OF REFS 11 |
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| 11. SUPPLEMENTARY NOTES Prepared for the U. S. Army Engineer Waterways Experiment Station, Vicksburg, Miss. | 12. SPONSORING MILITARY ACTIVITY Advanced Research Projects Agency; Service Agency: U. S. Army Materiel Command, Washington, D. C. | |

13. ABSTRACT

This volume contains a catalog of photographs of Thailand terrain features described in such a way that the information can be used in making estimations of their effects on the performance of ground vehicles. Results of a limited study of the effects of film emulsion on the acquisition of terrain information from aerial photographs are also presented.

KEYWORDS: Aerial photographs; Airphoto interpretation; Mobility; Terrain analysis; Terrain factors; Tropical regions; [Thailand]

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| 1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Mississippi | 2a. REPORT SECURITY CLASSIFICATION Unclassified |
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3. REPORT TITLE
MOBILITY ENVIRONMENTAL STUDY; A QUANTITATIVE METHOD FOR DESCRIBING TERRAIN FOR GROUND MOBILITY; DEVELOPMENT OF FACTOR-COMPLEX MAPS FOR GROUND MOBILITY

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
Volume VII of an eight-volume report

5. AUTHOR(S) (First name, middle initial, last name)
William K. Dornbusch, Jr.

| 6. REPORT DATE | 7a. TOTAL NO. OF PAGES | 7b. NO. OF REFS |
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| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY Advanced Research Projects Agency Service Agency: U. S. Army Materiel Command, Washington, D.C. |

13. ABSTRACT

Individual factor maps, devised as a product of the processes described in Volumes II, III IV, and V of this report, were compiled into a set of factor-family maps (surface composition, surface geometry, vegetation, and hydrologic geometry) by a process of sequential superpositioning. The factor-family maps were then compiled into two kinds of "factor-complex" maps: areal factor-complex maps, which display the areal extent of discrete combinations of factors value classes of three factor families (namely surface geometry, surface composition, and vegetation); and linear factor-complex maps, which display the occurrences of linear features (i.e., streams, canals, lakeshores, etc.) and the surface composition and vegetation immediately associated with them. Each discrete factor complex, whether areal or linear consists of a unique combination of factor value classes. Since the factors and factor value classes were chosen because of their significance to vehicle locomotion, it is presumed that each factor complex will affect vehicle performance in a specific and identifiable way. Because the data defining the factor complexes are precisely those required as terrain input values for the vehicle performance prediction model, the factor-complex maps furnish a comprehensive and concise data store for estimating the cross-country speeds of many military vehicles operating in terrains such as those of Thailand.

KEYWORDS: Mobility; Terrain analysis; Terrain factor maps; Terrain factors; Terrain mapping; Tropical regions; [Thailand]

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| 1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Mississippi | 2a. REPORT SECURITY CLASSIFICATION Unclassified |
| | 2b. GROUP |

3. REPORT TITLE
MOBILITY ENVIRONMENTAL RESEARCH STUDY; A QUANTITATIVE METHOD FOR EVALUATING TERRAIN FOR GROUND MOBILITY; TERRAIN FACTOR-FAMILY MAPS SELECTED AREAS

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
Volume VIII of report

5. AUTHOR(S) (Last name, first name, initial)

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|---|---|---|
| 6. REPORT DATE June 1966 | 7a. TOTAL NO. OF PAGES | 7b. NO. OF REFS |

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| b. PROJECT NO. | |
| c. ARPA ORDER NO. 400 | 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) |
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| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY Advanced Research Projects Agency; Service Agency: U. S. Army Materiel Command, Washington, D. C. |

13. ABSTRACT

The terrain factor-family maps presented in this volume were prepared by four teams, each with responsibility for a factor family. The methods used and techniques developed to compile these maps are discussed by factor family in the following volumes of this report series: Volume II, Surface Composition; Volume III, Surface Geometry; Volume IV, Vegetation, and Volume V, Hydrologic Geometry.

KEYWORDS: Mobility; Terrain analysis; Terrain factor maps; Tropical regions; [Thailand]

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| 1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Mississippi | 2a. REPORT SECURITY CLASSIFICATION Unclassified |
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3. REPORT TITLE

FEASIBILITY STUDY OF THE USE OF RADAR TO DETECT SURFACE AND GROUND WATER

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

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5. AUTHOR(S) (Last name, first name, initial)

Davis, Billy R.
Lundien, Jerry R.
Williamson, Albert N., Jr.

| 6. REPORT DATE | 7a. TOTAL NO. OF PAGES | 7b. NO. OF REFS |
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| Service Agent: U. S. Army Materiel Command Washington, D. C. 20315 | Advanced Research Projects Agency Washington, D. C. 20315 |

13. ABSTRACT

A study was made of the feasibility of using radar sensors as a remote means of detecting the presence and measuring the depth of surface water, and detecting the presence and measuring the depth to ground water. Also, previously begun studies were continued to relate radar returns, and the electrical soil constants they provided, to soil moisture content. Large laboratory soil samples were prepared at various moisture contents and with various depths of surface water and various depths to ground water. Standard pulsed radar sensors operating with frequencies of 297, 5870, and 9375 megacycles per sec through various angles of incidence were employed. Results indicate that the standard pulsed radar sensors can provide information to permit detection of surface water and an estimate of the moisture content of deep homogeneous soil samples. However, such sensors do not permit prediction of depth of surface water, presence of ground water, or depth to ground water. Systematic variation of surface-water depths and depths to ground water permitted an analytical solution for measuring surface- or ground-water depths, and led to the conclusion that properly designed radar systems could measure surface- and ground-water depths. Three such systems are proposed.

KEYWORDS: Groundwater; Laboratory tests; Radar; Remote sensing; Soil moisture prediction; Soils; Surface water; Trafficability

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| U. S. Army Engineer Waterways Experiment Station<br>Vicksburg, Mississippi | Unclassified |
| | 2b. GROUP |

3. REPORT TITLE

COMPARISON OF ENGINEERING PROPERTIES OF SELECTED TEMPERATE AND TROPICAL SURFACE SOILS

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final report

5. AUTHOR(S) (Last name, first name, initial)

Meyer, Marvin P.

| 6. REPORT DATE | 7a. TOTAL NO. OF PAGES | 7b. NO. OF REFS |
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| June 1966 | 238 | 26 |

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| b. PROJECT NO. 1-V-0-21701-A-046,<br>Trafficability and Mobility Research | Technical Report No. 3-732 |
| c. Task -02, Surface Mobility<br>d. ARPA order No. 400 | 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)<br>AD 486 478 |

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| Service Agent:<br>U. S. Army Materiel Command<br>Washington, D. C. 20315 | Advanced Research Projects Agency and<br>U. S. Army Materiel Command<br>Washington, D. C. 20315 |

13. ABSTRACT

Field and laboratory tests were conducted on 11 fine-grained soils from the temperate climate of the United States and 17 fine-grained soils from the tropical climates of Puerto Rico, Panama Canal Zone, Hawaii, and Thailand to determine the trafficability and other engineering properties of the soils. Soils were collected from the 6- to 12-in. layer for a wide range of parent materials. Temperate and tropical soils of each parent material were selected on the basis of their similarity in the Unified Soil Classification System and in topographic position. A comparison of physical, mineralogical, and chemical properties, and results of standard and special engineering tests indicate, with few exceptions, no significant differences between temperate and tropical soils from a similar parent material. It is concluded that temperate and tropical soils of similar parent material and Atterberg limits generally have other engineering properties that are similar and behave similarly when subjected to standard and special engineering laboratory tests. Differences in behavior between soils from each of the climates can be associated with differences in Atterberg limits.

KEYWORDS: Field tests; Laboratory tests; Parent materials (Soils); Soil property relations; Soil property variations; Temperate regions; Trafficability; Tropical regions; [Hawaii; Panama Canal Zone; Puerto Rico; Thailand; United States]

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| 1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Mississippi | 2a. REPORT SECURITY CLASSIFICATION Unclassified |
| | 2b. GROUP |

3. REPORT TITLE

TRAFFICABILITY CLASSIFICATION OF THAILAND SOILS

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final report

5. AUTHOR(S) (Last name, first name, initial)

Meyer, M. P.

| 6. REPORT DATE | 7a. TOTAL NO. OF PAGES | 7b. NO. OF REFS |
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| b. PROJECT NO. 1-V-0-21701-A-046, Trafficability and Mobility Research | Technical Report No. 3-753 |
| c. Task -02, Surface Mobility | 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) |
| d. ARPA Order No. 400 | AD 808 540 |

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| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY |
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| Service Agent: U. S. Army Materiel Command Washington, D. C. 20315 | Advanced Research Projects Agency and U. S. Army Materiel Command Washington, D. C. 20315 |

13. ABSTRACT


Pertinent soil trafficability data were collected during the wet season at 846 sites in Thailand. The soils were identified according to the Unified Soil Classification System and the U. S. Department of Agriculture textural classification system. Two general topographic positions (high topography and low topography) and two general levels of wetness were considered. A scheme for classifying soils according to their trafficability was developed. The scheme lists the soil types in order of decreasing trafficability under each of three topography-wetness level categories and shows the probability of successful passage on each soil for vehicles of known soil strength requirements. The scheme permits the estimation of the probability of a successful operation for given soil type, topography, and wetness-level conditions. If a choice of several routes and vehicles is available, the determination of the vehicles with the best chances of success over a given route or of the best route for given vehicles can be made.



KEYWORDS: Soil properties; Statistical analysis; Trafficability classification; Trafficability data; Tropical regions; [Thailand]


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| 1. ORIGINATING ACTIVITY (Corporate author)<br>U. S. Army Engineer Waterways Experiment Station<br>Vicksburg, Mississippi | | 2a. REPORT SECURITY CLASSIFICATION<br>Unclassified<br>2b. GROUP |
| 3. REPORT TITLE<br>FEASIBILITY STUDY OF THE USE OF VERY HIGH FREQUENCY RADIO IMAGING TECHNIQUES FOR DETECTION OF TUNNELS | | |
| 4. DESCRIPTIVE NOTES (Type of report and inclusive dates)<br>Final report | | |
| 5. AUTHOR(S) (First name, middle initial, last name)<br>Hansjoerg Nikodem | | |
| 6. REPORT DATE<br>March 1967 | 7a. TOTAL NO. OF PAGES<br>39 | 7b. NO. OF REFS<br>4 |
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| 10. DISTRIBUTION STATEMENT<br>Approved for public release; distribution unlimited. | | |
| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY<br>Assistant Secretary of the Army (R&D)<br>Department of the Army | |

13. ABSTRACT

A desk study and a laboratory scale-model study were made of the feasibility of using high resolution, very high frequency (VHF) mapping techniques to detect the presence of tunnel complexes such as occur in Vietnam. Detailed descriptions of proposed airborne systems for such detection are given. An evaluation of the feasibility of using these systems for tunnel detection was made by considering the known capabilities of existing radar systems for a similar purpose and the specific results of this scale-model study which involved the use of cylindrical and L-shaped Plexiglas rods submerged in water to simulate tunnels approximately 1 m in cross section buried beneath wet soils at depths of as much as 10 m. The results of the study indicate that tunnels could be detected in areas characteristic of a large part of Vietnam using the airborne systems described.

KEYWORDS: Laboratory tests; Radar; Tropical regions; Tunnel detection; [Vietnam]

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**1. ORIGINATING ACTIVITY (Corporate author)**
U. S. Army Engineer Waterways Experiment Station
Vicksburg, Miss. 39180

**2a. REPORT SECURITY CLASSIFICATION**
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**2b. GROUP**

**3. REPORT TITLE**
PILOT STUDY OF RESPONSE OF CV-2 AIRCRAFT TO IRREGULAR TERRAIN

**4. DESCRIPTIVE NOTES (Type of report and inclusive dates)**
Final report

**5. AUTHOR(S) (First name, middle initial, last name)**
Andrew J. Green, Jr.
Edgar S. Rush

| 6. REPORT DATE | 7a. TOTAL NO. OF PAGES | 7b. NO. OF REFS |
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| July 1967 | 108 | 10 |

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**10. DISTRIBUTION STATEMENT**
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**11. SUPPLEMENTARY NOTES**

**12. SPONSORING MILITARY ACTIVITY**
U. S. Army Materiel Command
Washington, D. C. 20315

**13. ABSTRACT**
The investigation reported herein was a pilot study undertaken to develop means of predicting the performance of a CV-2 aircraft on irregular terrain and of quantifying surface roughness. Special tests were conducted to ascertain the natural frequency and damping characteristics in both the vertical and horizontal directions of the elements of the aircraft. Landing, takeoff, and taxi tests were conducted at 15 field sites in three general areas; accelerometers and strain gages were used to record responses of 12 critical components of the aircraft. Simple mathematical models to predict the dynamic responses of certain of the aircraft components were developed for solution by both analog and digital computers and were verified by comparison with measured data. Because of certain assumptions used in the development of the models, the predicted data did not agree exactly with the actual data. Although the predictions were of useful accuracy, it is recommended that an analog model, excited by measured terrain data, be used to determine the adequacy of a surface for landings of the CV-2 aircraft. To obtain the terrain input, an outrigger trailer dynamometer with an actual prototype aircraft tire as the terrain follower is proposed.

KEYWORDS: Aircraft landing areas; Computerized models; Microgeometry; Short takeoff and landing aircraft; [CV-2 aircraft]

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1. ORIGINATING ACTIVITY (Corporate author)

U. S. Army Engineer Waterways Experiment Station
Vicksburg, Mississippi 39180

2a. REPORT SECURITY CLASSIFICATION

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3. REPORT TITLE

MOISTURE-STRENGTH CHARACTERISTICS OF SELECTED SOILS IN THAILAND
Vol I Analyses and Application of Data
Vol II Basic Data

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

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5. AUTHOR(S) (First name, middle initial, last name)

James G. Kennedy
John G. Collins
Margaret H. Smith

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11. SUPPLEMENTARY NOTES

Service Agent: U. S. Army Materiel Command, Washington, D. C. 20315

12. SPONSORING MILITARY ACTIVITY

Advanced Research Projects Agency
Directorate of Remote Area Conflict
Washington, D. C. 20315

13. ABSTRACT

Soil moisture, soil strength, and other relevant data were collected in Thailand during two wet seasons and one dry season for use in the development of methods to predict soil trafficability for off-road ground contact vehicles in Southeast Asia. Data were collected at 75 test sites distributed in eight geographic areas which had differences in soils, weather regimes, terrain, and land use.

From data collected monthly at the 75 sites, specific soil strength-moisture relations were derived to depict the changes in strength that corresponded to changes in moisture content. From data collected daily at 17 sites, specific soil moisture prediction relations were derived following procedures developed for sites in the United States. Results showed that the prediction methods were applicable to Thailand sites that were well drained. Modifications in the methods should be developed to account for the influence of water tables when present. Similarities in specific prediction relations between Thailand and the western hemisphere indicated that the development of average prediction relations is feasible.

Descriptions of Thailand and study areas are given in Appendix A. An application of the Thailand data, the derivation of a general soil moisture map for South Vietnam, is given in Appendix B. The basic data are summarized in Volume II.

KEYWORDS: Field tests; Soil moisture; Soil property relations; Soil strength; Terrain analysis; Trafficability; Trafficability data; Trafficability prediction; Tropical regions; [Thailand]

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| 1. ORIGINATING ACTIVITY (Corporate author)<br>U. S. Army Engineer Waterways Experiment Station<br>Vicksburg, Mississippi | | 2a. REPORT SECURITY CLASSIFICATION<br>Unclassified<br>2b. GROUP | |
| 3. REPORT TITLE<br>EVALUATION OF THE PERFORMANCE OF THE XM759 LOGISTICAL CARRIER | | | |
| 4. DESCRIPTIVE NOTES (Type of report and inclusive dates)<br>Final report | | | |
| 5. AUTHOR(S) (First name, middle initial, last name)<br>Barton G. Schreiner<br>Adam A. Rula | | | |
| 6. REPORT DATE<br>January 1968 | 7a. TOTAL NO. OF PAGES<br>151 | | 7b. NO. OF REFS<br>4 |
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| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY<br>U. S. Army Materiel Command<br>Washington, D. C. 20315 | | |

13. ABSTRACT

The XM759 was tested at sites in Virginia and Louisiana on a wide range of terrain conditions analogous to those of the Mekong Delta, South Vietnam. The off-road performance of the XM759 was compared with that of an M116, 1-1/2-ton Cargo Carrier, Amphibious, on the same test sites. An evaluation of the comparative performances of the XM759 and M116 in terms of terrain-vehicle relations (trafficability tests) and average speed for the terrain types tested (mobility tests) shows that the XM759 outperformed the M116 for most of the terrain conditions tested. Appendix A shows the computations necessary for determining VCI's of tracked vehicles. Appendix B presents a method for determining the effects of buoyancy on VCI's. Appendix C presents results of the terrain evaluation study to identify terrain types in several sections of South Vietnam and to locate similar areas in the Mississippi River Delta for vehicle test purposes.

KEYWORDS: Amphibious vehicles; Cargo vehicles; Field tests; Mobility; Temperate regions; Terrain analogs; Terrain analysis; Trafficability; Tropical regions; [M116 cargo carrier; Mekong Delta; Mississippi River Delta; XM759 logistical carrier]

DD FORM 1 NOV 65 1473 REPLACES DD FORM 1473, 1 JAN 64, WHICH IS OBSOLETE FOR ARMY USE.

Unclassified
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## DOCUMENT CONTROL DATA - R & D

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| 1. ORIGINATING ACTIVITY (Corporate author)<br>U. S. Army Engineer Waterways Experiment Station<br>Vicksburg, Mississippi | 2a. REPORT SECURITY CLASSIFICATION<br>Unclassified<br>2b. GROUP |

3. REPORT TITLE

VEGETATION STRUCTURAL CHARACTERISTICS AT SELECTED SITES IN THE PANAMA CANAL ZONE AND THAILAND

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final report

5. AUTHOR(S) (First name, middle initial, last name)

Harold W. West

| 6. REPORT DATE | 7a. TOTAL NO. OF PAGES | 7b. NO. OF REFS |
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| 8a. CONTRACT OR GRANT NO. | 9a. ORIGINATOR'S REPORT NUMBER(S) |
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10. DISTRIBUTION STATEMENT

Approved for public release; distribution unlimited.

| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY |
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| | Joint Chief of Staff; Service Agency: U. S. Army Materiel Command, Program Manager for Selected Ammunition, Degradation Effects Program, Picatinny Arsenal, Dover, N. J. |

13. ABSTRACT

A mission of the Degradation Effects Program (DEP), formerly Joint Environmental Effects Program (JEEP), is to extrapolate estimates of lethality and munition effectiveness in DEP test environments to Southeast Asian environments. If these extrapolations are to be reliable it is imperative that the environmental conditions of the test areas be similar to those of Southeast Asia. Accordingly, objective comparisons must be made of DEP test environments and Southeast Asian environments. This report describes and compares some significant vegetation structural characteristics of two selected DEP sites in the Piña and Balboa forests in the Panama Canal Zone (CZ) and four selected sites in two forests and two rubber plantations in Thailand. The vegetation structural characteristics considered herein include stem diameter, spacing, height, and number. Detailed ground measurements were available from seven data collection points in the CZ and four points in Thailand. Location maps, air and ground photographs, and the personal knowledge of the field survey personnel were used to provide a general description of each site. Site comparisons were made from an analysis of a series of graphs and histograms illustrating the number and cumulative number of stems and spacing and cumulative spacing of stems included in each 1-cm-stem-diameter class and each 1-m-stem-height class. Results revealed the CZ and Thailand forests to be remarkably similar when comparing number of stems in each stem diameter class; however, when comparing spacing of stems in each diameter class and in each height class the forests were somewhat dissimilar. The procedures used in sampling vegetation physiognomy are included as Appendix A. Computer print-outs of the vegetation data and results obtained from manipulation of these data are included as Appendix B.

KEYWORDS: Munition effectiveness; Tropical regions; Vegetation structure; [Panama Canal Zone; Thailand]

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| 1. ORIGINATING ACTIVITY (Corporate author)<br>U. S. Army Engineer Waterways Experiment Station<br>Vicksburg, Mississippi | 2a. REPORT SECURITY CLASSIFICATION<br>Unclassified<br>2b. GROUP |

3. REPORT TITLE

EVALUATION OF WES ANALYTICAL MODEL IN SELECTED TERRAINS (XM559E1 GOER TESTS AT CAMP GAGETOWN, NEW BRUNSWICK, CANADA)

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final report

5. AUTHOR(S) (First name, middle initial, last name)

Beryl G. Stinson

| 6. REPORT DATE | 7a. TOTAL NO. OF PAGES | 7b. NO. OF REFS |
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| 8a. CONTRACT OR GRANT NO. | 9a. ORIGINATOR'S REPORT NUMBER(S) |
| b. PROJECT NO. | Technical Report M-70-3 |
| c. | 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) |
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10. DISTRIBUTION STATEMENT

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| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY<br>U. S. Army Tank-Automotive Command<br>Warren, Michigan |

13. ABSTRACT


This study was conducted to (a) evaluate the performance of the 8-ton XM559E1 GOER when operating in selected Canadian terrains and (b) evaluate the capability of the WES analytical model to predict the performance of an 8-ton XM559E1 in selected Canadian terrains. Speed and motion resistance tests on secondary roads, cross-country speed tests, drawbar pull-slip tests, and towed off-road motion resistance tests were conducted. Where pertinent, soil, surface geometry, and vegetation data were collected before or after each test, and speed, vertical and longitudinal accelerations, percent wheel slip, and drawbar pull were measured. A comparison was made of actual performance and performance as predicted by the analytical model. The average of the absolute deviation of actual from predicted speeds for the tests conducted was 1.36 mph.



KEYWORDS: Field tests; Goer vehicles; Mathematical models; Military bases; Military vehicles; Mobility; Mobility models; Performance predictions; Performance tests (Vehicles); Terrain factors; [Camp Gagetown, Canada; XM559E1 Goer]


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| 1. ORIGINATING ACTIVITY (Corporate author)<br>U. S. Army Engineer Waterways Experiment Station<br>Vicksburg, Mississippi | 2a. REPORT SECURITY CLASSIFICATION<br>Unclassified<br>2b. GROUP |

3. REPORT TITLE

RELATIVE OFF-ROAD MOBILITY PERFORMANCE OF SIX WHEELED AND FOUR TRACKED VEHICLES IN SELECTED TERRAIN

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final report

5. AUTHOR(S) (First name, middle initial, last name)


J. K. Stoll
D. D. Randolph
A. A. Rula


| 6. REPORT DATE | 7a. TOTAL NO. OF PAGES | 7b. NO. OF REFS |
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| b. PROJECT NO. | Technical Report M-70-4 |
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10. DISTRIBUTION STATEMENT

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| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY |
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| | U. S. Army Materiel Command<br>Washington, D. C. |

13. ABSTRACT


The U. S. Army Engineer Waterways Experiment Station analytical model for predicting off-road ground mobility was used to evaluate the performance of six wheeled vehicles (M656, M54A2, M520, M37B1, M561, and M706) and four tracked vehicles (M548, M113A1, M116 and M571) over a selected traverse in Thailand. Maps were prepared to exhibit the terrain in terms of surface composition (soil consistency), surface geometry (slopes, rice-field dikes, etc.), vegetation, and hydrologic geometry (rivers and streams). The performance of each vehicle was evaluated in terms of average speed over the traverse and the center line, average fuel consumed over the traverse, and center-line cargo delivery rate. The vehicles were "run" over the traverse under dry-season conditions (60 or 40 rating cone index) and wet-season conditions (60 or 35 rating cone index). Four of the vehicles (M656, M54A2, M520, and M548) were tested also under wet-season conditions of 60 or 40 rating cone index. Appendix A describes the WES analytical model in an abbreviated form; Appendix B, the evaluation of the dynamic response of the M706; and Appendix C, some additional general analyses of the effects of soil strength on vehicle performance.



KEYWORDS: Field tests; Military vehicles; Mobility; Performance predictions; Terrain factors; Tropical regions; [Thailand]


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| 1. ORIGINATING ACTIVITY (Corporate author)<br>U. S. Army Engineer Waterways Experiment Station<br>Vicksburg, Mississippi | 2a. REPORT SECURITY CLASSIFICATION<br>Unclassified<br>2b. GROUP |

3. REPORT TITLE
PERFORMANCE OF RIVERINE UTILITY CRAFT (RUC) IN RIVERINE ENVIRONMENTS

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
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5. AUTHOR(S) (First name, middle initial, last name)
Barton G. Schreiner
Robert P. Smith
Charles E. Green

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10. DISTRIBUTION STATEMENT

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| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY<br>Naval Ship Systems Command<br>Department of the Navy<br>Washington, D. C. 20360 |

13. ABSTRACT Tests were conducted at four riverine sites in south Louisiana in November 1969 to evaluate the performance of the Riverine Utility Craft (RUC). The RUC is an amphibian that employs a locomotion concept based on the Archimedean screw. It moves by two counterrotating rotors that give forward and backward thrust; the rotors also serve to float the craft. The RUC is powered by two 380-hp engines and is designed to carry a payload of 2000 lb; the gross weight of the RUC is 13,000 lb. Specific purposes of the tests were to (a) develop performance-soil strength (rating cone index) relations in terms of maximum straight-line speed, maximum maneuver speed, and minimum time required to turn 180 deg, (b) determine water-exit capabilities, (c) determine the speed attained in a variety of test courses and terrain types commonly found in wetland marshes, and (d) determine the degree of analogy of the terrain types tested with terrain types at selected areas of the Mekong Delta, South Vietnam. The specific purposes of the test program were satisfied. Test results indicate that, in general, the RUC can operate in the riverine environments for which it was designed. The craft's performance is most effective in water and wet marshes of low soil strength. The RUC also has a performance capability in areas considered restrictive or even inaccessible to boats and other amphibious craft. Appendix A discusses the comparison of terrain types tested during the RUC program with those identified in selected areas of the Mekong Delta. Appendix B presents detailed descriptions of soil profiles along the Louisiana test courses.

KEYWORDS: Buoyant screw vehicles; Field tests; Hydrologic geometry factors; Mobility; Performance tests (Vehicles); Stream crossings; Trafficability; [Louisiana; Riverine Utility Craft]

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| 1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Miss. | 2a. REPORT SECURITY CLASSIFICATION Unclassified |
| | 2b. GROUP |

3. REPORT TITLE

Quantitative Description of Selected West German Terrain for Ground Mobility

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
Final Report


5. AUTHOR(S) (First name, middle initial, last name)

H. K. Woods
J. H. Shamburger


| 6. REPORT DATE | 7a. TOTAL NO. OF PAGES | 7b. NO. OF REFS |
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10. DISTRIBUTION STATEMENT

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| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY |
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| | U. S. Army Ballistic Research Laboratory Aberdeen Proving Ground, Maryland |

13. ABSTRACT


This study was performed to classify and map terrain for ground mobility purposes in accessible areas of three German military reservations (Baumholder, Bergen-Hohne, and Grafenwohr). The terrain was classified in terms of surface geometry, surface composition, vegetation, and hydrologic geometry factors that affect vehicle mobility. Mapping of the terrain factors was accomplished through interpretation of air photos. To provide the necessary ground control data for photo-interpretation processes, a field data collection program was conducted, and data were collected according to established procedures. The field data were tabulated and placed in established class ranges significant to ground mobility. Utilizing the field data, an air photo interpretation method was applied to estimate the established terrain factor-value classes from the geometric, tonal, and textural characteristics of the air photo patterns. Terrain characteristics were extrapolated from the sample to the unsampled areas, and factor-family maps at a scale of 1:25,000 were prepared of the three study areas. The factor-family maps were then compiled into areal and linear factor-complex maps. The areal factor-complex maps display the areal extent of discrete combinations of factor-value classes of surface geometry, surface composition, and vegetation factor families. The linear factor-complex maps display the factor values of linear features (i.e. streams, canals, road embankments, etc.) and the surface composition and vegetation associated with them.



KEYWORDS: Airphoto interpretation; Mobility; Temperate regions; Terrain analysis; Terrain classification; Terrain factor maps; Terrain mapping; [West Germany]


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U. S. Army Engineer Waterways Experiment Station
Vicksburg, Miss.

2a. REPORT SECURITY CLASSIFICATION
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2b. GROUP

3. REPORT TITLE
Evaluation of the Relative Off-Road Performance of 15 Vehicles in Synthalogous Theaters of Operation (STOP) Terrain Factor Complexes

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
A 2-volume report; Vol 2 contains data only

5. AUTHOR(S) (First name, middle initial, last name)
D. D. Randolph

6. REPORT DATE
May 1970

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Technical Report M-70-7, Vols 1-2

9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)
AD A032 765 (Vol I)
AD A032 836 (Vol II)

10. DISTRIBUTION STATEMENT
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11. SUPPLEMENTARY NOTES

12. SPONSORING MILITARY ACTIVITY
U. S. Army Materiel Command
Washington, D. C.

13. ABSTRACT

The purpose of this study was to evaluate the performance of ten wheeled and five tracked vehicles in the areal terrain factor complexes of the synthalogous (a coined word meaning "synthetic and analogous") theater of operations (STOP) using the U. S. Army Engineer Waterways Experiment Station (WES) analytical model.

Input data used by the model were (a) terrain data, (b) vehicle characteristics and performance data, and (c) terrain-vehicle performance relations.

Predictions were made in terms of speed, fuel consumption rate, and delivery rate for each vehicle in each areal terrain factor complex of the temperate, tropical, and arid climates of the STOP during the dry and wet seasons.

A two-volume report was prepared. Volume I contains the application of WES analytical model for evaluating vehicle performance in STOP terrain complexes, and Appendix A, which describes the analytical model. Volume II contains Appendices B, C, and D, which give the vehicle performance predictions determined by the analytical model for the tropical, arid, and temperate climate theaters, respectively.

KEYWORDS: Desert regions; Military vehicles; Mobility; Mobility models; Performance predictions; Synthalogous environment; Temperate regions; Terrain analysis; Terrain factors; Tropical regions

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| 1. ORIGINATING ACTIVITY (Corporate author)<br>U. S. Army Engineer Waterways Experiment Station<br>Vicksburg, Mississippi | 2a. REPORT SECURITY CLASSIFICATION<br>Unclassified<br>2b. GROUP |

3. REPORT TITLE

A MATHEMATICAL MODEL FOR PREDICTING THE FIRST-COLLISION PROBABILITIES OF SPHERES ON TREE BRANCHES AND STEMS

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final report

5. AUTHOR(S) (First name, middle initial, last name)

Hansjoerg J. Nikodem
Harold W. West

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| 6. REPORT DATE<br>June 1970 | 7a. TOTAL NO. OF PAGES<br>63 | 7b. NO. OF REFS<br>None |
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10. DISTRIBUTION STATEMENT

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| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY<br>Joint Chiefs of Staff<br>Service Agency, U. S. Army Materiel Command<br>Washington, D. C. |

13. ABSTRACT

In the Degradation Effects Program (DEP) an attempt is being made to obtain reliable estimates of the effectiveness and performance of nonnuclear antipersonnel and antimateriel munitions in various operational environments. Special consideration has been given to the development of suitable analytical models for predicting munition performance in vegetated environments. In effect, the mathematical model presented herein evaluates the probability that a sphere of selected size, entering a vegetation structure at a specific angle, will collide with a branch within any selected stratum above the ground. The model evaluates only first-collision probabilities. Input variables include sphere diameter, entrance angle, diameters of branch segments, and spatial (xyz) coordinates of branches and stems. All other things being equal, it is demonstrated that entrance angle significantly affects the depth of penetration into a forest canopy before first collision; e.g., collision probability increases with an increase in entry angle, as referenced to the vertical.

KEYWORDS: Mathematical models; Munitions effectiveness; Vegetation clearing; Vegetation structure; [Degradation Effects Program]

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| 1. ORIGINATING ACTIVITY (Corporate author)<br>U. S. Army Engineer Waterways Experiment Station<br>Vicksburg, Mississippi | 2a. REPORT SECURITY CLASSIFICATION<br>Unclassified<br>2b. GROUP |

3. REPORT TITLE
RELATIVE OFF-ROAD MOBILITY OF MBT70 AND M60A1E1 TANKS IN SELECTED TERRAINS IN WEST GERMANY

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
Final report

5. AUTHOR(S) (First name, middle initial, last name)
Adam A. Rula  Beryl G. Stinson
Claude A. Blackmon  Jack K. Stoll

| 6. REPORT DATE | 7a. TOTAL NO. OF PAGES | 7b. NO. OF REFS |
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| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY<br>U. S. Army Ballistics Research Laboratories, Aberdeen Proving Ground, Md., and U. S. Army Materiel Command, Washington, D. C. |

13. ABSTRACT


The speeds of the MBT70 and the M60A1E1 tanks over two selected traverses in West Germany were predicted by use of an analytical model. Vehicle performance relations extrapolated from previous field tests with similar vehicles and from terrain data (surface geometry, surface composition, vegetation, and hydrologic geometry) collected along and adjacent to the selected traverses were used in the analysis. The analytical model is described briefly, and the development of the vehicle-terrain relations necessary to make speed predictions over the traverses selected is discussed in detail. The application of the analytical model, the division of the traverses into discrete sections, the factors affecting speed in each section, and the prediction of the speed for each section are explained. A comparison of the predicted speeds for the two vehicles indicates the MBT70 to have the higher speed. It is suggested that actual field tests be conducted with the vehicles, when practical, to determine the accuracy of the predictions and to improve the quality of the relations used in the analytical model. Appendixes A, B, C, and D describe the determination of the minimum soil strength on which the vehicles can operate, the classes used to describe terrain for ground mobility purposes, the computer program used to predict dynamic response of the vehicles, and the effect of the driver's position on speed of the M60A1E1 over abrupt surface irregularities, respectively.



KEYWORDS: Mathematical models; Military vehicles; Mobility; Mobility models; Performance predictions; Tanks (Combat vehicles); Terrain factors; Vehicle speed; [Germany; M60A1E1 tank; MBT70 tank]


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| 1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Mississippi | 2a. REPORT SECURITY CLASSIFICATION Unclassified<br>2b. GROUP |

3. REPORT TITLE

EUROPEAN WATERWAYS STUDY, A PROCEDURE FOR DESCRIBING TACTICAL GAPS

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final report (3 volumes)

5. AUTHOR(S) (First name, middle initial, last name)

Richard R. Friesz   Katherine S. Fife   Warren E. Grabau
A. Paul Desmarais   William G. Willis

| 6. REPORT DATE | 7a. TOTAL NO. OF PAGES | 7b. NO. OF REFS |
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| b. PROJECT NO. | Technical Report M-70-12, Vols 1-3 |
| c. | 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) |
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| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY |
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| | U. S. Army Combat Developments Command Fort Belvoir, Va. |

13. ABSTRACT

An urgent need of the U. S. Army was to obtain statistical data defining the frequencies with which tactical gaps of specific kinds would be encountered in the European theater of operations. These data were to be used to determine the gap crossing requirements of a highly mobile army of the future. A study area in north-central Europe was selected, and a program was undertaken to acquire data on militarily significant gap characteristics in that area. These gap characteristics were: gap width, water width, water depth, current velocity, bank angles, bank heights, cone index (trafficability) of banks, and cone index of bed. Three main supply routes (MSR's) extending approximately west to east across the study area were arbitrarily selected for analysis of frequencies of occurrence of gap characteristics. This report consists of: a main text containing an introduction, a summary of statistical results, and recommendations and comments; and six appendixes describing the rationale, data acquisition, data processing, and data presentation procedures. The report is published in three volumes. Volume I includes the main text and Appendixes A (General Rationale and Procedure), B (Data Collection), C (Data Processing), D (Preparation of Statistical Data Base), and E (Statistical Terrain Model). The basic field and literature site data and the gap data from the statistical bands are presented in Volume II. Volume III contains a general orientation and index map, site location maps, and factor complex maps.

KEYWORDS: Hydrologic geometry factors; Hydrologic geometry mapping; Military operations; Military vehicles; Statistical analysis; Stream crossings; Terrain factor maps; Terrain models (Analytical);[Germany]

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1. ORIGINATING ACTIVITY (Corporate author)
U. S. Army Engineer Waterways Experiment Station
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2a. REPORT SECURITY CLASSIFICATION
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3. REPORT TITLE
INTRATHEATER TRANSPORTATION REQUIREMENT STUDY: A PROCEDURE FOR CONSTRUCTING SYNTHALOGOUS ENVIRONMENTS; Volume I, RATIONALE, Volume II, Maps

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
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5. AUTHOR(S) (First name, middle initial, last name)
Warren E. Grabau
John H. Shamburger

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9a. ORIGINATOR'S REPORT NUMBER(S)
Technical Report M-70-13

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AD 876 345L (Vol 1)
AD 876 382 (Vol 2)

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Vol. 2 - Approved for public release; distribution unlimited.

11. SUPPLEMENTARY NOTES

12. SPONSORING MILITARY ACTIVITY
Departments of the Army and Air Force; Intratheater Transportation Requirement Study Group

13. ABSTRACT The selection of environmental scenarios on which to "play" operations analysis problems has historically been very difficult, since no criteria exist for specifying the degree to which a specific region represent a broader area. There is no way to be sure that a chance combination of factors, existing only in the selected area, will not bias the results of the analysis. To meet this problem in determining intratheater transportation requirements, a procedure was developed for constructing synthalogous (from SYNTHetic but anALOGOUS) environments that are, in effect, statistical representations of very large areas proportioned to a size desired for a theater of operations. The developed procedure included isolating the six factors or factor families that are significant to intratheater transportation; classifying these factors in quantitative ranges; compiling real-world statistics of these factors within a set of data base countries; proportioning these real-world data to a theater of operations; and plotting the proportioned characteristics. The procedures were applied to map the planimetric distribution of all the factor or factor families in six "types" of synthalogous environments, i.e., deep tropic, shallow tropic, deep arid, shallow arid, temperate, and islands. Forty-six countries were used as a data base for the synthalogous environments, resulting in six synthalogous environments that were analogous with respect to the requirements of intratheater transportation but different in planimetry from the data base countries.

KEYWORDS: Military operations; Synthalogous environment; Terrain factor maps; Terrain models (Analytical); Transportation

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1. ORIGINATING ACTIVITY (Corporate author)
U. S. Army Engineer Waterways Experiment Station
Vicksburg, Mississippi

2a. REPORT SECURITY CLASSIFICATION
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2b. GROUP

3. REPORT TITLE
PENETRATION RESISTANCE OF SOILS; Report 2, GAMMA-RAY TECHNIQUES FOR NONDESTRUCTIVE MEASUREMENTS OF SOIL DENSITY AND DENSITY PROFILE

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
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5. AUTHOR(S) (First name, middle initial, last name)
Albert N. Williamson, Jr.

| 6. REPORT DATE | 7a. TOTAL NO. OF PAGES | 7b. NO. OF REFS |
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10. DISTRIBUTION STATEMENT
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11. SUPPLEMENTARY NOTES

12. SPONSORING MILITARY ACTIVITY
Assistant Secretary of the Army (R&D)
Department of the Army
Washington, D. C.

13. ABSTRACT A study was conducted to determine the feasibility of using measurements made with a multichannel gamma-ray spectrometer and a cobalt 60 radiation source for accurately determining soil density and resolving the density profile of layers. Measurements were first made on aluminum and steel plates to establish a standard reference for comparing soil density. Two samples of air-dry sand were constructed at different densities to a depth of approximately 120 and 125 cm in a pit 51.82 m long and 3.54 m wide. Measurements were made at depth intervals of 12.7 cm in each of six access holes located in the samples. The densities determined were compared with densities determined by nonnuclear means. Results of this study indicate that density can be measured accurately by the method described herein provided (a) the thickness through which the measurements are made is accurately measured, and (b) the source strength and detector are suitable for the distance over which the density is measured. The combination of source and detector that was used permitted defining soil density profiles. As a result of this study, it is recommended that the method described herein be used for nondestructive soil density measurements where the density beneath the surface of a sample must be known.

KEYWORDS: Gamma ray spectrometer; Nuclear methods; Soil density measuring devices

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3. REPORT TITLE
ENVIRONMENTAL CHARACTERIZATION OF MUNITIONS TEST SITES; VOLUME 1, TECHNIQUES AND ANALYSES OF DATA; Volume 2, DATA I; Volume 3, DATA II; Volume 4, SUPPLEMENTARY CHARACTERIZATIONS

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

5. AUTHOR(S) (First name, middle initial, last name)
Harold W. West, Richard R. Friesz, Elba A. Dardeau, Jr., Gerald F. Brown, Lynn E. Couch, Judith A. Parks

| 6. REPORT DATE | 7a. TOTAL NO. OF PAGES | 7b. NO. OF REFS |
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| b. PROJECT NO. | Technical Report M-71-3, Vols 1-4 |
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10. DISTRIBUTION STATEMENT

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| 11. SUPPLEMENTARY NOTES<br>Environmental Characterization Working Group Report 6 | 12. SPONSORING MILITARY ACTIVITY<br>U. S. Army Materiel Command<br>Project Manager for Selected Ammunition,<br>Degradation Effects Program, Dover, N.J. |

13. ABSTRACT


In the Degradation Effects Program (DEP), an experimental and analytical investigation is being made of the effects of the environment on the lethality of selected munitions. Existing munition lethality models are being refined by experimental field testing, and appropriate analytical models are being developed to obtain predictions of performance and effectiveness in a variety of environments. In support of field testing, detailed data on the enivornmental parameters affecting fuze functioning and fragment behavior are being obtained at all DEP test sites. This report presents the detailed environmental data collected by the U. S. Army Engineer Waterways Experiment Station (WES) at 53 sites in the United States, 162 sites in the Panama Canal Zone, and 8 sites in Australia, describes the various procedures employed for measuring and recording quantitative field data (detailed procedures are presented in Appendixes A-D), and describes the computerized techniques used to reduce, manipulate, analyze, and portray the data (Appendix E). Appendix F provides a cross index between the environmental data collected by WES and the munitions tests conducted. Data collected included vegetation structure and weight, vegetation surveys by the structural cell system and by the stem and branch survey system, and soil characterizations in terms of cone index, moisture content, and density. This report is contained in four volumes as follows: Volume I, Techniques and Analyses of Data; Volume II, Data I; Volume III, Data II; and Volume IV, Supplementary Characterizations.



KEYWORDS: Mathematical models; Munition effectiveness; Surface composition factors; Tropical regions; Vegetation clearing; Vegetation factors; [Australia; Degradation Effects Program; Panama Canal Zone]


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**1. ORIGINATING ACTIVITY (Corporate author)**
U. S. Army Engineer Waterways Experiment Station
Vicksburg, Miss.

**2a. REPORT SECURITY CLASSIFICATION**
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**3. REPORT TITLE**
A TECHNIQUE FOR QUANTIFYING FOREST STANDS FOR MANAGEMENT EVALUATIONS

**4. DESCRIPTIVE NOTES (Type of report and inclusive dates)**
Final report

**5. AUTHOR(S) (First name, middle initial, last name)**
Harold W. West
Hollis H. Allen, CPT, CE

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**9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)**
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**10. DISTRIBUTION STATEMENT**
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**11. SUPPLEMENTARY NOTES**

**12. SPONSORING MILITARY ACTIVITY**
Office, Chief of Engineers, U. S. Army
Washington D. C.

**13. ABSTRACT**
In this study, a system for describing the three-dimensional geometry of trees and stands is presented. The system consists of two survey instruments, a theodolite and transit, and basic triangulation principles. A spotting laser has recently been added to the system to facilitate the spotting of the tree nodes to be surveyed. Measurements were made of 16 Douglas-fir trees within a fertilized stand and an unfertilized stand in the A. E. Thompson Research Area, near Seattle, Washington, and two shortleaf pines and a hickory at the Texarkana Reservoir, near Texarkana, Texas. A measure of wood productivity (or growth) for the Douglas firs was made by sampling the trees before (April 1970) the start of and after (October 1970) a season's growth. Results of this study show significant differences in tree productivity as a result of fertilization: the total bole wood of the unfertilized Douglas fir increased by 1770 $cm^3/m^2$, while the fertilized Douglas fir increased by 2610 $cm^3/m^2$. Similar changes were noted in heights, bole diameters, etc. Various ways are presented in which the dimensioning system could be used in the resource management of forest lands. The procedures used in acquiring and recording of vegetation stem and branch data are contained in Appendix A. The basic data on the measured trees are contained in Appendix B.

KEYWORDS: **Vegetation descriptions; Vegetation structure; Vegetation surveys;[Seattle, Washington; Texarkana, Texas]**

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3. REPORT TITLE

SEISMIC AND ENVIRONMENTAL CHARACTERISTICS OF THE SENSOR TEST AREAS IN THE PANAMA CANAL ZONE; Report 1, DRY-SEASON CONDITIONS

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Report 1 of a series

5. AUTHOR(S) (First name, middle initial, last name)

Lewis E. Link
Harold W. West
Bob O. Benn

| 6. REPORT DATE | 7a. TOTAL NO. OF PAGES | 7b. NO. OF REFS |
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10. DISTRIBUTION STATEMENT

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| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY<br>U. S. Army Tropic Test Center<br>Fort Clayton, Canal Zone |

13. ABSTRACT

Field data were collected in the first part of a two-part study to establish seismic response characteristics, their distribution, and the environmental factors that control them in two U. S. Army Tropic Test Center seismic sensor test areas (Gamboa and Alpha) in the Panama Canal Zone. The data are assumed to represent dry-season conditions. Detailed seismic and environmental data collected are presented, and special seismic response tests (drop-hammer, man-walking, and ambient-noise) conducted in various environmental conditions at 9 sites in the Gamboa test area and 13 sites in the Alpha test area are described. Also discussed are the results (empirical regression equations) of a multicorrelation analysis used to relate the seismic response descriptors (peak particle velocity, peak summed particle velocity, and frequency) to the environmental parameters; the techniques used for mapping the seismic responses in the test areas; and the techniques for interpreting the seismic responses and terrain factor maps in terms of seismic intrusion detector performance. Results show that the seismic response from a drop-hammer energy source can be correlated with basic environmental parameters, and that sensor performance for one walking man can be approximated for dry-season conditions. The empirical equations, combined with the terrain factor complex maps, are shown to be a means of extrapolating seismic response characteristics to other test areas within the limits of the dry-season data used to generate the equations. The techniques used for evaluating the performance of seismic intrusion detectors do not represent the true interaction of the seismic signal and the sensor logic.

KEYWORDS: Environmental factors; Field tests; Seismic investigations; Seismic sensors; Tropical regions; [Panama Canal Zone]

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3. REPORT TITLE

SEISMIC AND ENVIRONMENTAL CHARACTERISTICS OF THE SENSOR TEST AREAS IN THE PANAMA CANAL ZONE; Report 2, WET-SEASON CONDITIONS

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Report 2 of a series

5. AUTHOR(S) (First name, middle initial, last name)

William F. Marcuson III
Roy E. Leach

| | | |
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| 6. REPORT DATE<br>May 1973 | 7a. TOTAL NO. OF PAGES<br>134 | 7b. NO. OF REFS<br>4 |

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10. DISTRIBUTION STATEMENT

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| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY<br>U. S. Army Tropic Test Center<br>Fort Clayton, Canal Zone |

13. ABSTRACT

Field data were collected in the second part of a two-part study to establish seismic response characteristics, their distribution, and the environmental factors that control them in two seismic sensor test areas (Gamboa and Alpha), which are located at the U. S. Army Tropic Test Center (TTC) in the Panama Canal Zone. The data were gathered during the 1971 wet season. Detailed seismic and environmental data are presented, and special seismic response tests (drop-hammer, man-walking, vegetation-effects, repeatability, and ambient-noise) conducted in various environmental conditions at 24 sites in the Gamboa test area and 11 sites in the Alpha test area are described. In addition to seismic response and terrain factor complex maps prepared from the measured data, the empirical regression equations resulting from a multicorrelation analysis are shown to relate the seismic response descriptors (peak particle velocity, peak summed particle velocity, and frequency) to the environmental parameters. Wet- and dry-season environmental data were combined so that empirical equations were developed that apply to both climatic conditions. The empirical equations, combined with the terrain factor complex maps, are shown to be a means of extrapolating seismic response characteristics to other test areas within the limits of the wet- and dry-season data used to generate the equations. Wet- and dry-season seismic responses are compared. The wet-season data exhibited lower peak particle velocity, higher peak summed particle velocity, and lower frequency content. The analytical procedures used to develop the empirical equations did not always produce satisfactory agreement between predicted and observed values; therefore, development of a theoretical SID (seismic intrusion detector) performance prediction model is recommended. Since the Panama test area exhibited considerable site-to-site variation in the seismic response for the controlled drop-hammer energy source during both the wet and dry seasons, it is recommended that all sites used by the testing agency be calibrated at the time of testing by obtaining data for specified seismic and environmental parameters.

KEYWORDS: Environmental factors; Field tests; Seismic investigations; Seismic sensors; Tropical regions; [Panama Canal Zone]

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| 1. ORIGINATING ACTIVITY (Corporate author)<br>U. S. Army Engineer Waterways Experiment Station<br>Vicksburg, Mississippi | 2a. REPORT SECURITY CLASSIFICATION<br>Unclassified<br>2b. GROUP |

3. REPORT TITLE

DETERMINING PRESENCE, THICKNESS, AND ELECTRICAL PROPERTIES OF STRATIFIED MEDIA USING SWEPT-FREQUENCY RADAR

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
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5. AUTHOR(S) (First name, middle initial, last name)

Jerry R. Lundien

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10. DISTRIBUTION STATEMENT

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| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY |
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| | Office, Chief of Engineers, U. S. Army<br>Washington, D. C., and<br>U. S. Army Engineer Topographic Laboratories, Ft. Belvoir, Va. |

13. ABSTRACT

The ability of a swept-frequency radar system operating under field conditions to detect the presence and measure the thickness of layered substrata and to determine the electrical properties of the materials in these substrata was studied. Reflectivity on sections of asphaltic concrete pavement structures (i.e. asphalt highway) of various subsurface layer thicknesses was measured by a specially designed microwave system operating over the frequency range of 0.25 to 8.0 GHz at perpendicular incidence. Test results indicated that swept-frequency radar measurements can be used to estimate power reflectance from the surface material of highway structures and to determine the amplitude of the subsurface contribution. Also, interference patterns, produced in the power reflectance curves, can be used to calculate the thickness of each layer of the structure.

KEYWORDS: Flexible pavements; Layered systems; Microwaves; Pavement thickness measurement; Radar signals

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| 1. ORIGINATING ACTIVITY *(Corporate author)*<br>U. S. Army Engineer Waterways Experiment Station<br>Vicksburg, Mississippi | 2a. REPORT SECURITY CLASSIFICATION<br>Unclassified<br>2b. GROUP |

3. REPORT TITLE
EFFECTS OF ENVIRONMENT ON MICROSEISMIC WAVE PROPAGATION CHARACTERISTICS IN SUPPORT OF SID TESTING AT FORT BRAGG, N. C.; Report 1, DRY-SEASON CONDITIONS

4. DESCRIPTIVE NOTES *(Type of report and inclusive dates)*
Report 1 of a series

5. AUTHOR(S) *(First name, middle initial, last name)*
Harold W. West

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10. DISTRIBUTION STATEMENT
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| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY<br>U. S. Army Test and Evaluation Command<br>U. S. Army Airborne, Communications and Electronics Board<br>*Fort Bragg*, N. C. |

13. ABSTRACT

Field data were collected in the first part of a two-part study to describe the environmental conditions and the seismic response characteristics in 10 test areas at Fort Bragg, N. C. The data are assumed to be representative of the dry-season terrain conditions. Detailed seismic and environmental data collected are presented and seismic response tests (e.g. drop hammer, man walking, vehicles, and ambient and induced noises) conducted in various environmental conditions at 14 sites within the test areas are described. Also presented are the predictions of seismic intrusion detector (SID) performance (i.e. detection range) for three prediction schemes (theoretical seismic wave computer model, analog computer model, and a nomograph or graphical solution), and a comparison of the predicted values with field measured SID performances is given. Techniques are also presented for mapping the significant terrain factors and the general seismic response descriptors (i.e. peak particle velocity, peak summed particle velocity, and frequency) within the primary test area (SID area 3), and for interpreting the prepared terrain factor and seismic response maps in terms of SID performance. Results show that the 10 SID test areas contain considerable site-to-site variation in drop-hammer seismic response and that the response is significantly affected by soil surface conditions and vegetation ground covers. The seismic responses resulting from background noises have significant effects upon SID testing. Additional work is required to develop a SID performance prediction scheme adequate for SID test results for both man-walking and vehicle targets. The theoretical prediction scheme offers a general solution to the seismic wave propagation problem but needs further development to account for the transfer of seismic energy from the energy source into the propagating medium, the addition of viscous soil damping coefficients that approximate site conditions, and a forcing function that accounts for near-field wave propagation. All prediction methods require specific terrain and seismic data for their execution; therefore, test sites must be calibrated if predictions are required. The terrain factor map and the seismic response factor map for SID area 3 provide data on an areal basis for use as input to the three prediction systems for estimating SID performance for man-walking energy sources during the dry season. Appendix A presents terrain site descriptions and supplementary seismic data.

KEYWORDS: Environmental effects; Environmental factors; Microseismic waves; Military bases; Seismic investigations; Seismic sensors; Wave propagation; Fort Bragg, N.C.

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| 4. TITLE (and Subtitle)<br>EFFECTS OF ENVIRONMENT ON MICROSEISMIC WAVE PROPAGATION CHARACTERISTICS IN SUPPORT OF SID TESTING AT FORT BRAGG, N. C.; COMPARISON OF SUMMER- AND WINTER-SEASON CONDITIONS | | 5. TYPE OF REPORT & PERIOD COVERED<br>Report 2 of a series<br>6. PERFORMING ORG. REPORT NUMBER |
| 7. AUTHOR(s)<br>Thomas L. Engdahl<br>Harold W. West | | 8. CONTRACT OR GRANT NUMBER(s) |
| 9. PERFORMING ORGANIZATION NAME AND ADDRESS<br>U. S. Army Engineer Waterways Experiment Station<br>Mobility and Environmental Systems Laboratory<br>P. O. Box 631, Vicksburg, Miss. 39180 | | 10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS<br>Project No. 1T062112A131 |
| 11. CONTROLLING OFFICE NAME AND ADDRESS<br>U. S. Army Test and Evaluation Command<br>U. S. Army Airborne, Communication and Electronics Board, Fort Bragg, N. C. 28307<br>and<br>U. S. Army Materiel Command<br>Alexandria, Va. 22304 | | 12. REPORT DATE<br>December 1974<br>13. NUMBER OF PAGES<br>211<br>15. SECURITY CLASS. (of this report)<br>Unclassified |
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18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

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| Environmental effects | Seismic investigations |
| Environmental factors | Seismic sensors |
| Microseismic waves | Wave propagation |
| Military bases | [Fort Bragg, N. C.] |

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Field data were collected in a two-part study to describe the environmental conditions and the seismic response characteristics in 10 test areas at Fort Bragg, North Carolina. The data are assumed to be representative of the summer (wet) and winter (dry) seasons. Detailed seismic and environmental data collected are presented and seismic response tests (e.g. drop-hammer, man-walking, vehicles, and ambient noises) conducted in various environmental conditions at 16 sites for the summer season and 14 sites for the winter season within

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20. ABSTRACT (Continued).

the test areas are described and compared. Also presented and compared are the predictions of seismic intrusion detector (SID) performance (i.e. detection range) for the two seasons. Theoretical techniques are also presented for predicting seismic responses for a man walking and a vehicle (M151). The theoretical prediction scheme offers a general solution to the target-ground interaction and the seismic wave propagation problem and takes into account the transfer of seismic energy from the energy source into the propagating medium, viscous soil damping coefficients that approximate site conditions, and transmission coefficients that account for wave propagation. A comparison of predicted seismic signals with field measured data is given. Techniques are also presented for mapping significant terrain factors and the general seismic response descriptors (i.e. peak particle velocity, peak summed particle velocity, and frequency) within the primary test area (SID area 3), and for interpreting the prepared terrain and seismic response maps in terms of SID performance. Results show that the 10 SID test areas contain considerable site-to-site variation and a definite season-to-season trend in drop-hammer seismic response and that the response is significantly affected by soil surface conditions and vegetative ground covers. Season-to-season changes were not excessive for subsurface terrain parameters and a single measurement may suffice for SID testing purposes, while surface terrain factors should always be considered in designing SID test scenarios. All prediction methods require specific terrain and seismic data for their execution; therefore, test sites must be calibrated if predictions are required. Appendix A presents detailed procedures used in conducting seismic response tests.

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| 1. ORIGINATING ACTIVITY (Corporate author)<br>U. S. Army Engineer Waterways Experiment Station<br>Vicksburg, Mississippi | 2a. REPORT SECURITY CLASSIFICATION<br>Unclassified<br>2b. GROUP |

3. REPORT TITLE

EFFECTS OF TERRAIN ON THE PROPAGATION OF MICROSEISMIC WAVES AND IMPLANTATION CHARACTERISTICS OF AIR-DELIVERED SENSORS AT FORT HUACHUCA, ARIZONA; WET- AND DRY-SEASON CONDITIONS

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

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5. AUTHOR(S) (First name, middle initial, last name)

Harold W. West
Behzad Rohani

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| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY<br>U. S. Army Test and Evaluation Command<br>U. S. Army Electronics Proving Ground<br>Fort Huachuca, Arizona |

13. ABSTRACT

To obtain a quantitative basis for experiment design decisions regarding evaluation of seismic intrusion detector (SID) systems, test areas were selected (one for hand-emplaced SID's and six for air-implanted SID's) and special seismic and environmental field experiments were conducted at Fort Huachuca during Aug 1971 and Mar 1972. Data obtained were assumed to be representative of wet- and dry-terrain conditions at the test sites. The selection of the SID test areas, their wet- and dry-terrain characteristics, and the procedures for collecting environmental data and conducting seismic response tests (i.e. man-walking, drop-hammer, M151 wheeled and M577 tracked vehicles, ambient and induced noises) are described. Also presented are experimental detection distance data on the hand-emplaced miniaturized SID (MINISID), and experimental data on the depth of penetration and angle of impact of the air-delivered seismic intrusion detector/short (ADSID/S). A theoretical system for modeling the quantitative effects of the terrain on SID detection performance and methods by which SID test results can be extrapolated from one site condition to another are also presented. This system has been implemented on the Waterways Experiment Station computer and involves acquisition of terrain and seismic data for input to the model; exercising the model for each set of terrain factor data; and portraying the performance predictions for each set of terrain and seismic factor data. A system of equations for determining soil penetration and deceleration of air-delivered SID's is included.

KEYWORDS: Microseismic waves; Military bases; Seismic investigations; Seismic sensors; Wave propagations; (Fort Huachuca, Ariz.)

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3. REPORT TITLE

A MATHEMATICAL MODEL FOR PREDICTING MICROSEISMIC SIGNALS IN TERRAIN MATERIALS

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final report

5. AUTHOR(S) (First name, middle initial, last name)

Jerry R. Lundien
Hans Nikodem

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| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY |
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| | Defense Special Projects Group and<br>U. S. Army Materiel Command |

13. ABSTRACT

The mathematical model presented herein allows the user to make predictions for the wave amplitude and frequency content of microseismic signals that would interact with a seismic intrusion detection device at the surface of the ground. These signals are propagated as a result of a force applied to the surface of a medium (stress) which in turn causes a corresponding motion to travel away from the source. Efforts were made to keep the operation of the model as general as possible such that little restriction is placed on either the source of the seismic signal or the ground media through which the signal propagates. As a result, the source signal is needed in the form of a time domain stress signal at the points of contact on the ground. The ground media can have any seismic profile that can be approximated by a layered viscoelastic structure. Examples are given of two sites to illustrate the variation in predicted signals due to multiple mode Rayleigh wave propagation, varying damping factors, varying ranges from the source, and input stress signal shapes.

KEYWORDS: Mathematical models; Microseismic waves; Seismic investigations

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3. REPORT TITLE

DETECTION CAPABILITY OF A STRAIN-SENSITIVE CABLE SENSOR

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

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5. AUTHOR(S) (First name, middle initial, last name)

Richard A. Weiss

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| | Defense Special Projects Group U. S. Army Mobility Equipment Research and Development Center |

13. ABSTRACT

Theoretical and experimental studies were conducted to determine the stress and strain on a buried strain-sensitive cable sensor (SSCS) caused by a known time-dependent surface load applied at various horizontal distances from the cable. Theoretical and experimental values of the current and voltage generated by the SSCS were also obtained as a function of the perpendicular distance between the surface load and the SSCS, and a mathematical model for predicting current and voltage generated by a buried SSCS was developed. The time-dependent stress and strain on the buried SSCS depend on the viscoelastic properties of the soil and on the characteristics of the surface load. With appropriate modification, the viscoelastic soils theory will describe soil areas where permanent deformation of the soil occurs under the applied load. Therefore, in this report a soils model developed for the SSCS that is adequate for all soil sites for which appropriate descriptive soil parameters are available is described. The soil parameters that are necessary for a complete determination of the performance of a buried SSCS are listed and a means of obtaining them is given.

KEYWORDS: Mathematical models; Pressure cells (Soils); Sensors; Stress-strain relations (Soils)

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3. REPORT TITLE
APPLICATION OF REMOTE SENSORS TO ARMY FACILITY MANAGEMENT

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
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5. AUTHOR(S) (First name, middle initial, last name)
Lewis E. Link, Jr.
John H. Shamburger

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| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY |
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| | Office, Chief of Engineers, U. S. Army<br>Washington, D. C. |

13. ABSTRACT
A study was conducted to determine the feasibility of applying remote sensing techniques to Army needs for data in environmental monitoring, resource management, and master planning at multipurpose military installations in the continental United States. The environmental data requirements for these purposes were defined, and a general assessment was made of the applicability of current photographic, thermal infrared, and microwave imaging systems to obtain these data. Aerial photographic techniques were found to be the ones most generally applicable to acquisition of data relevant to basic environmental conditions. Prototype products, consisting of maps of basic environmental conditions, cultural features, and land use were produced from aerial photography of Fort Belvoir, Virginia, and a surrounding area. The maps demonstrated the feasibility of using remote sensing techniques to produce an environmental base line for a multipurpose military installation and to detect changes in environmental conditions over specific time periods. On the basis of this study, it was concluded that two major areas require increased research attention: (a) The formulation of analytical models that relate terrain and other environmental conditions to the construction, maintenance, and operational use of military bases and related regions so that the effects of activities related to military base development and utilizations on the regional environment can be reliably predicted. It has been demonstrated that many of the environmental factors required as input to such a model can be obtained through analysis of remote sensor products; but it is clear that such analyses are hedged about with uncertainties due to a lack of rigorous techniques for interpreting remote sensor system products. This leads directly to the second research requirement. (b) The development of rigorous analytical methods of obtaining relevant environmental data from the products of remote sensor systems. Such methods are envisioned as being guided by systems analysis models of the complex interactions of sensor system, electromagnetic radiation, and the terrain. Appendix A describes remote sensing principles and systems currently in use.

KEYWORDS: Airphoto interpretation; Environmental factors; Infrared waves; Microwaves; Military bases; Remote sensing; Sensors

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| 7. AUTHOR(s)<br>John H. Shamburger<br>Harry K. Woods | | 8. CONTRACT OR GRANT NUMBER(s) |
| 9. PERFORMING ORGANIZATION NAME AND ADDRESS<br>U. S. Army Engineer Waterways Experiment Station<br>Mobility and Environmental Systems Laboratory<br>P. O. Box 631, Vicksburg, Miss. 39180 | | 10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS<br>Project 4A662707A890 |
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Airphoto interpretation
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Military bases
Remote sensing
Sensors
Terrain maps
[Fort Belvoir, Va.]

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

A study was performed to validate environmental baseline factor maps of the Fort Belvoir study area, which were prepared through air-photo interpretation without the aid of any supplementary data. A field data collection program was conducted to provide data to be compared with the information derived from the analysis of the aerial photos. It was found that the air-photo interpretation was quite accurate, but that increased accuracy would result if ground truth data were available to the interpreters during the interpretation process.

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ANALYTICAL STUDY OF GROUND-SURFACE SHIELDING CHARACTERISTICS OF SELECTED ROAD TERRAINS; Volume I, DEVELOPMENT OF SHIELDING MODEL AND ANALYSES OF RESULTS

**4. DESCRIPTIVE NOTES (Type of report and inclusive dates)**
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**5. AUTHOR(S) (First name, middle initial, last name)**
Harold W. West
Phillip L. Doiron
Judith A. Parks

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**11. SUPPLEMENTARY NOTES**

**12. SPONSORING MILITARY ACTIVITY**
U. S. Army Materiel Systems Analysis Agency
Aberdeen Proving Ground, Maryland

**13. ABSTRACT**
The mathematical model presented herein allows the user to determine the amount of shielding from munition bursts offered by the ground surface to targets (vehicles, personnel, etc.) on and moving along roads or in cross-country terrains. In the shielding model it is assumed that fragments and projectiles travel in straight-line trajectories; therefore, the amount of shielding offered by the ground surface to a target is calculated along the optical paths between the burst point and selected points on the target. The shielding values given by the model are maximum values. Shielding characteristics in terms of probability of shielding for a point(s) on a target, or in terms of average shielding for a one-dimensional target of a specified height, can be obtained. The model variables include target height, number of target height intervals, locations of five target positions, elevations of six munition height of bursts (HOB), and eight horizontal target-to-HOB ranges. Shielding results are provided for six road sites near Vicksburg, Miss., selected to be representative of a wide range of road configurations known to occur in various geographical regions. The ground-surface shielding results obtained for the six road sites show that shielding of a one-dimensional vertical target is significantly affected by both distance (or range) and burst height, and that shielding does not change appreciably for the different target positions that were evaluated along the center line of the road. However, since five target locations were in relatively uniform areas, it is believed that target location would have a significant effect on shielding on those roads that contain closely spaced cuts and fills. Of the six sites for which shielding calculations were made, site 6 contained the greatest amount of shielding; this amount increased with increasing range and decreased only slightly with increasing burst height. At sites 1 through 5, the shielding of the target varied between 0 and 25 percent for the different ranges and burst heights equal to and greater than 100 cm. For a burst height of 0 cm (i.e. ground burst), the shielding of the target varied between 10 and 55 percent for the different ranges. Appendix A describes the general procedures used in the acquisition and recording of on-site three-dimensional topographic data and presents the topographic data that were collected at the six road sites. Appendix B describes the interpolation procedure used in determining a fine grid of equally spaced discrete elevation (i.e. 2-m grid points) from a set of randomly located (field measured) elevation points. Appendix C presents examples of the tabular output of the shielding model. Volume II (published in limited quantity) contains the total tabular output of the shielding model.

KEYWORDS: Mathematical models; Munition effectiveness; Surface geometry; Terrain

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3. REPORT TITLE

ANALYTICAL STUDY OF GROUND-SURFACE SHIELDING CHARACTERISTICS OF SELECTED ROAD TERRAINS; Volume II, OUTPUT OF SHIELDING MODEL

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5. AUTHOR(S) (First name, middle initial, last name)

Harold W. West
Phillip L. Doiron
Judith A. Parks

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13. ABSTRACT

This volume contains the tabular output of the shielding model for each of the six road sites described in Volume I.

KEYWORDS: Mathematical models; Munition effectiveness; Roads; Terrain data

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3. REPORT TITLE

COMPUTER-CALCULATED GEOMETRIC CHARACTERISTICS OF MIDDLE MISSISSIPPI RIVER SIDE CHANNELS; Volume I: PROCEDURES AND RESULTS; Volume II: SIDE-CHANNEL CONTOUR MAPS

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

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5. AUTHOR(S) (First name, middle initial, last name)

Victor E. LaGarde
Samuel J. Winfrey

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| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY<br>U. S. Army Engineer District, St. Louis<br>Office of Environmental Resources<br>St. Louis, Missouri |

13. ABSTRACT

Several geometric characteristics of water-basin regimes, including basin size and shape, area underwater at specific water depth, and cross-sectional area, are commonly associated with benthic, plankton, and fish community population structures, although little quantitative data are available to support the association. This two-volume report describes a general procedure that was developed to calculate values of selected parameters used to define the above-mentioned geometric characteristics of any water-basin regime. The procedure was successfully applied to yield quantitative information for those parameters for 18 side channels of the Middle Mississippi River. Which of the parameters selected as quantitative descriptors of the characteristics are best indicators of animal community population structures is expected to be determined as a result of other projects currently under way at the U. S. Army Engineer Waterways Experiment Station. Volume I contains a description of the procedure and the results of implementing it. Volume II contains a set of computer-plotted contour maps for the 18 side channels.

KEYWORDS: Computerized simulation; Ecology; Hydraulic geometry; Hydrologic geometry factors; Hydrologic geometry mapping; Rivers; [Mississippi River Basin]

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| 7. AUTHOR(s)<br>Lewis E. Link, Jr. | | 8. CONTRACT OR GRANT NUMBER(s) |
| 9. PERFORMING ORGANIZATION NAME AND ADDRESS<br>U. S. Army Engineer Waterways Experiment Station<br>Mobility and Environmental Systems Laboratory<br>P. O. Box 631, Vicksburg, Miss. 39180 | | 10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS<br>Project 4A162121A896, Task 01, Work Unit 003 |
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18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

- Airphoto interpretation
- Computer programs
- Computerized simulation
- Environmental factors
- Military bases
- Remote sensing

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Airborne remote sensors provide a potentially expedient technique for obtaining environmental data for baseline descriptions of multipurpose military installations or of impact of activities on the environment within a reasonable time and cost framework. Although the feasibility of using remote sensing techniques for these purposes has been demonstrated, the acquisition of imagery of sufficient quality to provide the necessary data for the many and diverse environmental features and phenomena of interest requires systematic and quantitative planning. This report presents an analytical procedure (referred to herein as

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20. ABSTRACT (continued).

the remote sensing simulation model) that provides a means for selecting a sensor system and mission profile objectively to enhance imagery for specific purposes. The model is computerized and calculates the amount of contrast that will occur between two features of interest on a photographic image as a function of reflectance properties of materials, atmospheric conditions, solar zenith angle, sensor altitude, and sensor characteristics. Illustrations of model application to two hypothetical problems are given. The remote sensing simulation model provides a general tool for acquisition of photographic remote sensing techniques and evaluation of the applicability of these techniques to specific or general problem areas. Analytical tools, such as this model, provide the foundation from which more rigorous and detailed user manuals can be constructed. Appendix A describes photographic remote sensor systems, and Appendix B documents the remote sensing simulation model computer program. Appendix C lists the basic information components of master plans for Army installations.

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| 7. AUTHOR(s)<br>Daniel H. Cress and Lewis E. Link, Jr. | | 8. CONTRACT OR GRANT NUMBER(s) |
| 9. PERFORMING ORGANIZATION NAME AND ADDRESS<br>U. S. Army Engineer Waterways Experiment Station<br>Mobility and Environmental Systems Laboratory<br>P. O. Box 631, Vicksburg, Mississippi 39180 | | 10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS<br>Project 4A762720A896,<br>Task 01, Work Unit 003 |
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| Airphoto interpretation | Photography | [Fort Carson, Colo.] |
| Environmental analysis | Remote sensing | |
| Environmental factors | Sensing | |
| Military vehicles | Sensors | |

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report demonstrates the application of a procedure developed for the systematic application of photographic remote sensor systems to specific environmental data acquisition problems. Of particular importance to this procedure is a quantitative approach to predicting a proper mission profile (i.e. film-filter combinations, scale, etc.) as a function of properties of the features of interest and the surrounding environment. The application of the

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20. ABSTRACT (Continued).

procedure to an environmental management problem at a military facility within CONUS, Fort Carson, Colorado, is discussed. The primary emphasis of the work is on the acquisition of data relevant to measurement of the effects of maneuvering vehicles on the environment in two training areas (80 $km^2$) on the post. The parameter selected for measurement is the length of vehicle paths per unit area, referred to as vehicular usage. The quantitative approach for mission design is applied to: (a) enhance the contrast between the vehicle paths and background vegetation through selection of the proper film-filter combination and (b) define a photographic scale such that the feature (vehicle paths) can be resolved. A statistical technique for measuring the vehicular usage is developed to enable efficient interpretation of the data. The final product is a map showing the distribution of vehicular usage in the two training areas. An obvious application of the map is to support scheduling of training in areas of lowest vehicular usage and to identify areas subject to severe environmental damage. Two secondary data collection problems (identification of areas of near-surface moisture caused by seepage through reservoirs, and detection of aquatic plants) are examined to illustrate the differences in the informational content of two different imageries.

Appendix A describes the Fort Carson soil units, Appendix B illustrates the selection of a mission profile within cost and equipment constraints, and Appendix C discusses the method used to measure vehicle paths on the photographic imagery.

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| REPORT DOCUMENTATION PAGE | | READ INSTRUCTIONS BEFORE COMPLETING FORM |
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| 1. REPORT NUMBER<br>Technical Report M-74-8 | 2. GOVT ACCESSION NO.<br>AD A026 718 | 3. RECIPIENT'S CATALOG NUMBER |
| 4. TITLE (and Subtitle)<br>THE USE OF REMOTE SENSING SYSTEMS FOR ACQUIRING DATA FOR ENVIRONMENTAL MANAGEMENT PURPOSES; REPORT 3, A NOMOGRAM FOR COMPUTING OPTICAL DENSITY CONTRAST | | 5. TYPE OF REPORT & PERIOD COVERED<br>Report 3 of a series<br>6. PERFORMING ORG. REPORT NUMBER |
| 7. AUTHOR(s)<br>Lewis E. Link, Jr.<br>James R. Stabler | | 8. CONTRACT OR GRANT NUMBER(s) |
| 9. PERFORMING ORGANIZATION NAME AND ADDRESS<br>U. S. Army Engineer Waterways Experiment Station<br>Mobility and Environmental Systems Laboratory<br>P. O. Box 631, Vicksburg, Mississippi 39180 | | 10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS<br>Project 4A762720A896, Task 01, Work Unit 003 |
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17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Airphoto interpretation
Computerized simulation
Environmental analysis
Environmental factors
Optical density
Remote sensing

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Previous efforts as part of this program resulted in a new capability for predicting photographic-image optical density contrasts. The product of the efforts was a computerized system model that provides a rigorous, quantitative means of objectively selecting a sensor system and mission profile to enhance the success of a remote sensing data acquisition program. The execution of the model requires computer facilities and specialized personnel. A graphical form of the model was developed to provide a simple planning tool that can be
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20. ABSTRACT (Continued).

applied by users having a wide range of backgrounds and without computer facilities. This report presents a nomogram for predicting optical density contrasts on aerial photographs. The concept and formulation of the nomogram are discussed and an example of its application presented. The accuracy of the nomogram with respect to the computer program from which it was derived is also evaluated.

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| REPORT DOCUMENTATION PAGE | | READ INSTRUCTIONS BEFORE COMPLETING FORM |
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| 1. REPORT NUMBER<br>Technical Report M-75-3 | 2. GOVT ACCESSION NO.<br>AD A017 853 | 3. RECIPIENT'S CATALOG NUMBER |
| 4. TITLE (and Subtitle)<br>DEVELOPMENT OF PROCEDURE FOR AIRFIELD SITE EVALUATION | | 5. TYPE OF REPORT & PERIOD COVERED<br>Final report<br>6. PERFORMING ORG. REPORT NUMBER |
| 7. AUTHOR(s)<br>Malcolm P. Keown<br>Judith A. Parks<br>Jack K. Stoll | | 8. CONTRACT OR GRANT NUMBER(s) |
| 9. PERFORMING ORGANIZATION NAME AND ADDRESS<br>U. S. Army Engineer Waterways Experiment Station<br>Moility and Environmental Systems Laboratory<br>P. O. Box 631, Vicksburg, Miss. 39180 | | 10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS<br>Project No.<br>4A062103A859, Task 05<br>4A162121AT31, Task 02 |
| 11. CONTROLLING OFFICE NAME AND ADDRESS<br>Office, Chief of Engineers, U. S. Army<br>Washington, D. C. 20314 | | 12. REPORT DATE<br>October 1975<br>13. NUMBER OF PAGES<br>93 |
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18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Airfield site selection
Airfields
Computer programs
Evaluations
Site investigations

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report describes the mathematical techniques used as the basis for developing a set of related computer programs that collectively represent an automated procedure for airfield site evaluation. A model that numerically delineates the topography of a selected site and a model for the layout of an airfield are analytically examined for compatibility. If the airfield and site geometries are determined to be compatible, construction time and cost

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20. ABSTRACT (Continued).

estimates can be generated for vegetation clearing, topsoil stripping, excavation at a cut location and haulage of soil from the cut to a fill location, spreading of fill, soil compaction, and placement of a runway surface. The runway surfaces included in the inventory of the evaluation procedure are unsurfaced with or without membrane, light-duty mat with or without membrane, medium-duty mat with or without membrane, flexible pavement, and rigid pavement. Total time and costs are computed for construction of the airfield by a specified engineer construction unit at a selected site for any of the available surfaces. Appendix A describes the method used to calculate the runway surface elevation required to satisfy the change of slope criterion specified for the airfield. All variables used in the text are defined in Appendix B.

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| REPORT DOCUMENTATION PAGE | | READ INSTRUCTIONS BEFORE COMPLETING FORM |
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| 1. REPORT NUMBER: Technical Report M-76-2 | 2. GOVT ACCESSION NO.: AD A021 188 | 3. RECIPIENT'S CATALOG NUMBER |
| 4. TITLE (and Subtitle): EXPERIMENTAL VERIFICATION OF A THEORETICAL LOADING FUNCTION DESCRIBING MOMENTUM TRANSFER FROM AN EXPLOSION TO A TREE STEM | | 5. TYPE OF REPORT & PERIOD COVERED: Final report |
| | | 6. PERFORMING ORG. REPORT NUMBER |
| 7. AUTHOR(s): Malcolm P. Keown, Jack K. Stoll, Hansjoerg Nikodem | | 8. CONTRACT OR GRANT NUMBER(s) |
| 9. PERFORMING ORGANIZATION NAME AND ADDRESS: U. S. Army Engineer Waterways Experiment Station, Mobility and Environmental Systems Laboratory, P. O. Box 631, Vicksburg, Mississippi 39180 | | 10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: Project 4A062112A859, Task 05 |
| 11. CONTROLLING OFFICE NAME AND ADDRESS: Office, Chief of Engineers, U. S. Army, Washington, D. C. 20314 | | 12. REPORT DATE: January 1976 |
| | | 13. NUMBER OF PAGES: 106 |
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18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Dynamic loads
Explosion effects
Forests
Helicopter landing zones
Munition effectiveness
Trees
Vegetation clearing

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This study was conducted to validate methods previously developed by the Waterways Experiment Station to theoretically predict the clearing capability of a given explosive at a selected site in a forested area to be used as a helicopter landing zone. The prediction depends largely on a theoretical loading function used in the solution of a partial differential equation that describes the motion of a tree stem being acted upon by a shock front.

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20. ABSTRACT (Continued)

Special equipment was designed to evaluate the loading function in terms of the impulse experienced by free-flying logs, which represented the tree stems. Seven explosions of 0.09-metric-ton TNT equivalent yield were detonated to provide adequate data for evaluation. Each explosion was monitored for the correct yield and shock-front symmetry. The results show good agreement between the stem loading predicted by the theoretical loading function and the actual loading experienced by the logs during the tests.

Appendix A describes the development of a failure criterion for a tree stem under dynamic loading by a shock front. Specification of the failure criterion requires the solution of the partial differential equation discussed above. The solution of the equation using the finite difference method is presented in detail.

Appendix B demonstrates a method to rapidly determine the remnant height of a tree stem for wide variations in explosive yield and tree properties. The solution is in the form of a nomograph.

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| REPORT DOCUMENTATION PAGE | | READ INSTRUCTIONS BEFORE COMPLETING FORM |
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| 1. REPORT NUMBER<br>Technical Report M-76-6 | 2. GOVT ACCESSION NO.<br>AD A025 733 | 3. RECIPIENT'S CATALOG NUMBER |
| 4. TITLE (and Subtitle)<br>USE OF AUTOMATED REMOTE SENSING TECHNIQUES TO DEFINE THE MOVEMENT OF TOW-GENERATED SUSPENDED MATERIAL PLUMES ON THE ILLINOIS AND UPPER MISSISSIPPI RIVERS | | 5. TYPE OF REPORT & PERIOD COVERED<br>Final report<br>6. PERFORMING ORG. REPORT NUMBER |
| 7. AUTHOR(s)<br>Lewis E. Link, Jr.<br>Albert N. Williamson, Jr. | | 8. CONTRACT OR GRANT NUMBER(s) |
| 9. PERFORMING ORGANIZATION NAME AND ADDRESS<br>U. S. Army Engineer Waterways Experiment Station<br>Mobility and Environmental Systems Laboratory<br>P. O. Box 631, Vicksburg, Miss. 39180 | | 10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS |
| 11. CONTROLLING OFFICE NAME AND ADDRESS<br>U. S. Army Engineer District, St. Louis<br>210 North 12th Street<br>St. Louis, Mo. 63101 | | 12. REPORT DATE<br>June 1976<br>13. NUMBER OF PAGES<br>56 |
| 14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office) | | 15. SECURITY CLASS. (of this report)<br>Unclassified<br>15a. DECLASSIFICATION/DOWNGRADING SCHEDULE |

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18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Aerial photographs
Infrared rays
Optical density
Remote sensing
Water analysis
[Illinois River]
[Mississippi River]

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Sequential color-infrared aerial photos and corresponding surface water samples were obtained at selected sites on the Illinois and Upper Mississippi Rivers to examine the movement of tow-generated suspended material plumes. The aerial photos were digitized with a scanning microdensitometer, and optical density values were extracted for correlation with suspended material concentration data obtained by laboratory analysis of the water samples.

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20. ABSTRACT (Continued).

Correlation of the optical density and concentration values for each site and for sample positions at each site did not produce a statistically significant relation between the variables. The lack of correlation is believed to have been caused primarily by a small range in suspended material concentration values and by a small range in the optical density values (due to underexposure of the photos). In addition, the complex nature of the plumes made it difficult to measure the full spectrum of conditions at the limited number of ground sampling sites.

The poor correlation between optical density and concentration values prevented quantitative definition from the imagery of the distribution of suspended material concentrations at the sites as a function of time. Digital data handling procedures were used to enhance the visibility on the imagery of the tow-generated plumes. Enhanced images were produced by automated film-writing techniques, and these images were interpreted to define the time variations in the tow-generated suspended material plumes for the tows monitored at each site. The procedures applied were successful in delineating the movement and dissipation of the tow-generated plumes under favorable sun and water conditions.

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| 1. REPORT NUMBER<br>Technical Report M-76-7 | 2. GOVT ACCESSION NO.<br>AD B012 041L | 3. RECIPIENT'S CATALOG NUMBER |
| 4. TITLE (and Subtitle)<br>A COMPARATIVE ANALYSIS OF SELECTED SEISMIC AND SEISMIC-ACOUSTIC TARGET CLASSIFIERS | | 5. TYPE OF REPORT & PERIOD COVERED<br>Final report |
| | | 6. PERFORMING ORG. REPORT NUMBER |
| 7. AUTHOR(s)<br>Daniel H. Cress | | 8. CONTRACT OR GRANT NUMBER(s) |
| 9. PERFORMING ORGANIZATION NAME AND ADDRESS<br>U. S. Army Engineer Waterways Experiment Station<br>Mobility and Environmental Systems Laboratory<br>P. O. Box 631, Vicksburg, Miss. 39180 | | 10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS<br>Project 1X764723DL73 |
| 11. CONTROLLING OFFICE NAME AND ADDRESS<br>Project Manager, Remotely Monitored<br>Battlefield Sensor System,<br>Fort Monmouth, New Jersey 07703 | | 12. REPORT DATE<br>June 1976 |
| | | 13. NUMBER OF PAGES<br>160 |
| 14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office) | | 15. SECURITY CLASS. (of this report)<br>Unclassified |
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17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

| | |
|---|---|
| Acoustics | Seismic sensors |
| Aircraft | Simulation |
| Military vehicles | Vehicle signatures |

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)


The purpose of this study was to evaluate the features and logics of the Honeywell, Inc., and GTE Sylvania seismic only and seismic-acoustic target classifiers, to identify their most significant features, and to compare their performances.

The approach used to carry out such an evaluation was based on analysis of the performances of the features and logics for separating


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20. ABSTRACT (Continued)

the desired target classes (i.e. wheeled vehicles, tracked vehicles, fixed- and rotary-wing aircraft, and personnel). Seismic and acoustic simulation models were used to generate signatures of such targets in a spectrum of worldwide environments. Features used by the target classifiers were extracted from these signatures. Those features that provided the best separation (relative to the other features) between signatures from each pair of target classes (for example, separation of wheeled vehicle signatures from tracked vehicle signatures) were identified.

The seismic features employed by the GTE Sylvania target classifiers tended to perform better than those of the Honeywell, Inc., target classifiers. The acoustic features of the Honeywell, Inc., seismic-acoustic target classifier (SATC) performed better than those of the GTE Sylvania SATC. The GTE Sylvania SATC and seismic target classifier (STC) (i.e. comprised of features and a logic form) were identified as having better overall performance when tested against the seismic and acoustic data bases than the Honeywell, Inc., SATC or STC.

The features used by both the Honeywell, Inc., and GTE Sylvania target classifiers were quite strongly affected by environmental conditions.

Recommendations for the improvement of the present classifiers include independently using seismic and acoustic energy (i.e., the present logic form combines the effects of both in the same manner), allowing the sensors to be adaptive to the local environment, and supplying a quantity proportional to the probability of correct classification with the class information. It is also recommended that new features and classification techniques be investigated that make use of relatively narrow lines in the frequency spectrum (i.e. having bandwidths on the order of 2 Hz) associated with physical properties of targets such as cylinder firing frequencies and track "slap" frequencies.

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| 1. REPORT NUMBER<br>Technical Report M-76-8 | 2. GOVT ACCESSION NO.<br>AD A030 728 | 3. RECIPIENT'S CATALOG NUMBER |
| 4. TITLE (and Subtitle)<br>PROCEDURES FOR THE SYSTEMATIC EVALUATION OF REMOTE SENSOR PERFORMANCE AND QUANTITATIVE MISSION PLANNING | | 5. TYPE OF REPORT & PERIOD COVERED<br>Final report<br>6. PERFORMING ORG. REPORT NUMBER |
| 7. AUTHOR(s)<br>Lewis E. Link, Jr. | | 8. CONTRACT OR GRANT NUMBER(s) |
| 9. PERFORMING ORGANIZATION NAME AND ADDRESS<br>U. S. Army Engineer Waterways Experiment Station<br>Mobility and Environmental Systems Laboratory<br>P. O. Box 631, Vicksburg, Miss. 39180 | | 10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS<br>Project 4A162121A896<br>Task 01, Work Unit 003 |
| 11. CONTROLLING OFFICE NAME AND ADDRESS<br>Office, Chief of Engineers, U. S. Army<br>Washington, D. C. 20314 | | 12. REPORT DATE<br>August 1976<br>13. NUMBER OF PAGES<br>287 |
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18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Infrared rays
Mathematical models
Remote sensing
Sensors

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)


Effective application of remote sensing techniques to civil engineering and environmental problems requires the selection of the sensor systems that will best provide the information desired. Because of the many phenomena involved and the lack of a simple means to consider them collectively, planning remote sensing missions has been done subjectively, quantitatively on a piecemeal basis, or solely on the experience of the investigator. None of these offers a systematic means to optimize the mission for acquisition of

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20. ABSTRACT (Continued).

specific information types as a function of the many variables involved. The purpose of this study was to (a) quantitatively examine the natural phenomena that influence the information content of remote sensing imagery obtained in the visible and infrared (IR) portions of the electromagnetic spectrum, and (b) from the knowledge gained through these examinations, develop analytical tools for planning remote sensing missions and provide guidance for application of photographic and thermal IR sensor systems to civil engineering and environmental problems.

This study consisted of (a) the development of analytical models that allow systematic control of the major variables that influence the character of imagery produced by photographic and thermal IR scanning sensor systems, and (b) formulation from the models of simple, but comprehensive, tools for planning photographic and thermal IR remote sensing missions. The basic concept of the models and the mission planning tools is an organized and quantitative means for evaluating photographic and thermal IR sensor systems for particular data acquisition jobs by contrasting the magnitude and spectral content of energy received by the sensors with performance characteristics of the sensor systems. The ability to quantitatively predict performance provides the capability necessary to quantitatively plan missions for specified types of data. Variables considered include the source of electromagnetic radiation, interactions with terrain materials, interactions with the atmosphere, sensor altitude, time of day, time of year, source-sensor position, and sensor spectral and spatial characteristics.

The Photographic Systems Simulation Model and the Thermal IR Systems Simulation Models provide a new dimension for systematic evaluation of remote sensor performance and quantitative mission design previously unavailable to personnel applying remote sensors to civil engineering and environmental problems. The systems models and the graphical products derived from the models allow selection of the best (of those available) sensor system for a specific data acquisition problem by providing a means of quantitatively comparing the expected performances of a variety of sensors for the specific data needs. In addition, the models and derived products provide a means of quantitatively planning the remote sensing mission to optimize the information content of the resulting imagery for the specific data needs.

The systems models consider the major phenomena that influence the informational content of photographic and thermal IR sensors imagery. As is usually the case, a variety of analytical methods could have been used to model these phenomena. The methods used were chosen to provide a comprehensive description of the phenomena and yet minimize the number of hard-to-get inputs required to execute the models. As such, the models were oriented toward the people who apply remote sensors rather than those who design them.

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| REPORT DOCUMENTATION PAGE | | READ INSTRUCTIONS BEFORE COMPLETING FORM |
|---|---|---|
| 1. REPORT NUMBER<br>Technical Report M-76-10 | 2. GOVT ACCESSION NO. | 3. RECIPIENT'S CATALOG NUMBER |
| 4. TITLE (and Subtitle)<br>BASELINE ELEMENTS AND INFORMATION SOURCES FOR ENVIRONMENTAL QUALITY MANAGEMENT OF MILITARY INSTALLATIONS | | 5. TYPE OF REPORT & PERIOD COVERED<br>Final report<br>6. PERFORMING ORG. REPORT NUMBER |
| 7. AUTHOR(s)<br>Malcolm P. Keown<br>Marshall R. Weathersby | | 8. CONTRACT OR GRANT NUMBER(s) |
| 9. PERFORMING ORGANIZATION NAME AND ADDRESS<br>U. S. Army Engineer Waterways Experiment Station<br>Mobility and Environmental Systems Laboratory<br>P. O. Box 631, Vicksburg, Miss. 39180 | | 10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS<br>Project 4A762720A896<br>Task 006 |
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| 18. SUPPLEMENTARY NOTES | | |
| 19. KEY WORDS (Continue on reverse side if necessary and identify by block number)<br>Environmental analysis<br>Information systems<br>Military bases<br>Temperate regions | | |

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The National Environmental Protection Act of 1969 requires that the Army conduct its activities without degrading the environmental quality of the surrounding area. The immediate goals of environmental quality management as established by the Act could not be attained by Army facilities using available technology. For the Army's future mission to be compatible with the Nation's environmental quality standards, the Office, Chief of Engineers, U. S. Army,
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20. ABSTRACT (Continued).

established a research program on 1 July 1974 entitled "Environmental Quality for Construction and Operation of Military Facilities" with the primary responsibility for conducting the program assigned to the Construction Engineering Research Laboratory (CERL) at Champaign, Illinois.

As part of CERL's response to this assignment, an automated system was structured to identify impacts of Army activities on the environment. This system, called the Environmental Impact Computer System (EICS), requires that the user have some knowledge of Army activities and the environment to be able to collect required input data and to interpret the output of the EICS. CERL requested that the U. S. Army Engineer Waterways Experiment Station compile a list of environmental baseline elements and assemble a catalog of environmental information sources to aid personnel using the EICS as well as to provide background material for those personnel charged with preparation of Environmental Impact Assessments and Statements.

The information sources are available via an information system structured for this study. Access to this system can be obtained by contacting CERL.

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| REPORT DOCUMENTATION PAGE | | READ INSTRUCTIONS BEFORE COMPLETING FORM |
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| 1. REPORT NUMBER<br>Technical Report M-76-11 | 2. GOVT ACCESSION NO.<br>AD A033 359 | 3. RECIPIENT'S CATALOG NUMBER |
| 4. TITLE (and Subtitle)<br>AN AUTOMATED SYSTEM FOR COLLECTING, PROCESSING, AND DISPLAYING ENVIRONMENTAL BASELINE DATA | | 5. TYPE OF REPORT & PERIOD COVERED<br>Final report<br>6. PERFORMING ORG. REPORT NUMBER |
| 7. AUTHOR(s)<br>Harold W. West<br>Herman M. Floyd | | 8. CONTRACT OR GRANT NUMBER(s) |
| 9. PERFORMING ORGANIZATION NAME AND ADDRESS<br>U. S. Army Engineer Waterways Experiment Station<br>Mobility and Environmental Systems Laboratory<br>P. O. Box 631, Vicksburg, Miss. 39180 | | 10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS<br>Project 4A762720A896<br>Task 01, Work Unit 006 |
| 11. CONTROLLING OFFICE NAME AND ADDRESS<br>Office, Chief of Engineers, U. S. Army<br>Washington, D. C. 20314 | | 12. REPORT DATE<br>November 1976<br>13. NUMBER OF PAGES<br>94 |
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18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Computer analysis
Data acquisition
Data processing
Information retrieval
Sensors
Terrain data
[Pine Bluff Arsenal, Ark.; Fort McClellan, Ala.; Fort Carson, Colo.; Mobile, Ala.; Satartia, Miss.]

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

A system for automated collecting, processing, and displaying of environmental baseline data is described. The functions of the system, consisting of data collection with an automated field station, data processing, and data display options, are discussed. Also included are descriptions of the environmental sensors that are being used with the field station. Data that were obtained with the system at 15-, 30-, and 60-min sampling intervals

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20. ABSTRACT (Continued).

over a period of several months at Pine Bluff Arsenal, Arkansas, Fort Carson, Colorado, Fort McClellan, Alabama, Upper Blakely Island near Mobile, Alabama, and Satartia, Mississippi, are analyzed. Example environmental data are presented in computer formats available with the system. An estimated cost (1976) of the automated field station and selected array of sensors is provided (Appendix A).

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| 1. REPORT NUMBER<br>Technical Report M-76-12 | 2. GOVT ACCESSION NO. | 3. RECIPIENT'S CATALOG NUMBER |
| 4. TITLE (and Subtitle)<br>COMPUTER PROCEDURE FOR CALCULATING AND DISPLAYING THE BOUNDARIES OF A WATERSHED | | 5. TYPE OF REPORT & PERIOD COVERED<br>Final report<br>6. PERFORMING ORG. REPORT NUMBER |
| 7. AUTHOR(s)<br>Victor E. LaGarde<br>Margaret H. Smith | | 8. CONTRACT OR GRANT NUMBER(s) |
| 9. PERFORMING ORGANIZATION NAME AND ADDRESS<br>U. S. Army Engineer Waterways Experiment Station<br>Mobility and Environmental Systems Laboratory<br>P. O. Box 631, Vicksburg, Miss. 39180 | | 10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS<br>Project 6.11.01.A,<br>4A061101A91D<br>Task 02, Work Unit Q6 |
| 11. CONTROLLING OFFICE NAME AND ADDRESS<br>Assistant Secretary of the Army (R&D)<br>Washington, D. C. 20314 | | 12. REPORT DATE<br>December 1976<br>13. NUMBER OF PAGES<br>45 |
| 14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office) | | 15. SECURITY CLASS. (of this report)<br>Unclassified<br>15a. DECLASSIFICATION/DOWNGRADING SCHEDULE |

16. DISTRIBUTION STATEMENT (of this Report)

Distribution limited to U. S. Government agencies only; computer program documentation; December 1976. Other requests for this document must be referred to U. S. Army Engineer Waterways Experiment Station, ATTN: WESFV.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Computer programs
Computerized simulation
Surface geometry mapping
Watersheds
[Fort Carson Military Reservation, Colo.]

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

A computer program was developed to automatically calculate and display the topographic limits of a watershed using a three-dimensional description (i.e. an elevation grid array) of the geographic area enclosing the watershed. Required inputs to the program, in addition to the three-dimensional array, are the locations of the watershed discharge point and flow channels within the watershed carrying water to the discharge point.

(Continued)

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

Unclassified
SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

20. ABSTRACT (Continued).

The algorithm used by the computer program to calculate the topographic limits of the watershed is based on the fact that water flows from a higher to a lower ground-surface elevation. The calculation procedure begins with the spaces in the elevation grid array identified as the watershed discharge point and flow channels. Backtracking from these grid spaces to neighboring grid spaces with higher elevations proceeds until a space is reached that has no neighbors with higher elevations. This grid space is assumed to be on the watershed ridgeline. The procedure is repeated until all backtracking routes have been followed. The calculated result is displayed by the program as a high-speed-printer map for overlaying the input elevation grid array. Results are also output onto a magnetic tape for subsequent analysis or for Calcomp plotting of an overlay to a U. S. Geological Survey or other topographic sheet.

Input to and products from a sample delineation of a watershed on the Fort Carson Military Reservation, Colorado, are used to illustrate the procedures. Boundaries of the Fort Carson watershed also were derived by two other methods. In one, method 2, the boundary was interpreted from a topographic map and aerial stereophotography of the region. In the other, method 3 (the usual manual interpretation), only topographic map information was used. The results of methods 1 (computer method) and 3 were compared to the results of method 2, which was assumed to be the most accurate. The watershed boundary calculated by the computer program compared more favorably to the boundary interpreted by method 2 than by method 3. On the basis of comparison by area, the computer-calculated watershed was 113 percent of the area interpreted by method 2, and the area interpreted by method 3 was only 67 percent of that interpreted by method 2.

Unclassified
Security Classification

M, E

**DOCUMENT CONTROL DATA - R&D**

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|---|---|
| 1. ORIGINATING ACTIVITY (Corporate author)<br>U. S. Army Engineer Waterways Experiment Station<br>Vicksburg, Miss. | 2a. REPORT SECURITY CLASSIFICATION<br>Unclassified<br>2b. GROUP |

3. REPORT TITLE
REPORT ON
TRAFFICABILITY CONDITIONS AND AIRFIELD SITE SELECTION IN AN AREA IN NORFOLK COUNTY, EAST ANGLIA, ENGLAND

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
Final report.

5. AUTHOR(S) (Last name, first name, initial)
Anonymous

| 6. REPORT DATE | 7a. TOTAL NO. OF PAGES | 7b. NO. OF REFS |
|---|---|---|
| November 1952 | 51 | 0 |

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|---|---|
| 8a. CONTRACT OR GRANT NO.<br>b. PROJECT NO. 8-70-05-01<br>c. Project Title: Trafficability of Soils as Related to the Mobility of<br>d. Military Vehicles | 9a. ORIGINATOR'S REPORT NUMBER(S)<br>Miscellaneous Paper No. 4-19<br>9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) |

10. AVAILABILITY/LIMITATION NOTICES
Approved for public release; distribution unlimited.

| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY |
|---|---|
| | Chief of Engineers, DA<br>Washington, D. C. 20315 |

13. ABSTRACT

This study was performed as an outgrowth of the interest expressed by the British War Office in the apparent progress made by the United States in identifying soils from aerial photography. It was a joint undertaking performed by personnel from Purdue University and WES. Two separate tests were performed: one, simulating emergency operation conditions, was completed in a 72-hour period; the other, simulating routine intelligence production, was completed within a six-week period. The following finished products were furnished: (1) necessary explanatory text and legends; (2) an overlay showing cross-country movement conditions based on evaluation of soils, relief, vegetation, obstacles, and seasonal variations; (3) an overlay showing areas suitable for airfields, based on soils, relief, drainage, obstacles, and availability of construction materials; (4) an overlay showing extent of photo coverage and indication of quality of photography; and (5) a statement giving the team composition and number of man-hours required for the production and reproduction stages of the test results.

KEYWORDS: Airfield site selection; Airphoto interpretation; Trafficability; Trafficability mapping; [England]

DD FORM 1 JAN 64 1473 Unclassified

Unclassified

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DOCUMENT CONTROL DATA - R & D

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|---|---|
| 1. ORIGINATING ACTIVITY (Corporate author)<br>U. S. Army Engineer Waterways Experiment Station<br>Vicksburg, Mississippi | 2a. REPORT SECURITY CLASSIFICATION<br>Unclassified<br>2b. GROUP |
| 3. REPORT TITLE<br>A STUDY OF MOISTURE-CONTENT DETERMINATIONS ON SELECTED SOILS | |
| 4. DESCRIPTIVE NOTES (Type of report and inclusive dates) | |
| 5. AUTHOR(S) (First name, middle initial, last name) | |
| 6. REPORT DATE<br>September 1954 | 7a. TOTAL NO. OF PAGES<br>7<br>7b. NO. OF REFS |
| 8a. CONTRACT OR GRANT NO.<br>b. PROJECT NO.<br>c.<br>d. | 9a. ORIGINATOR'S REPORT NUMBER(S)<br>Miscellaneous Paper No. 4-73<br>9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)<br>AD 041 085 |
| 10. DISTRIBUTION STATEMENT<br>Approved for public release: distribution unlimited. | |
| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY<br>Office of the Chief of Engineers, Airfields Branch, Engineering Division, Military Construction |

13. ABSTRACT

Report describes the tests performed and the results of the investigation, together with a suggested laboratory procedure for determining reliable moisture-content values on those soils that give erratic values in the standard laboratory moisture-content test.

KEYWORDS: Soil moisture; Soil tests (Laboratory); Water content determination (Soils)

M,E

**DOCUMENT CONTROL DATA - R&D**

*(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)*

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|---|---|
| 1. ORIGINATING ACTIVITY (Corporate author)<br>U. S. Army Engineer Waterways Experiment Station<br>Vicksburg, Miss. | 2a. REPORT SECURITY CLASSIFICATION<br>Unclassified<br>2b. GROUP |

3. REPORT TITLE

TRAFFICABILITY SURVEY OF SELECTED AREAS, CAMP STEWART, GEORGIA

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final report

5. AUTHOR(S) (Last name, first name, initial)

Anonymous

| 6. REPORT DATE | 7a. TOTAL NO. OF PAGES | 7b. NO. OF REFS |
|---|---|---|
| November 1954 | 20 | 0 |

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|---|---|
| 8a. CONTRACT OR GRANT NO. | 9a. ORIGINATOR'S REPORT NUMBER(S)<br>Miscellaneous Paper No. 4-101 |
| b. PROJECT NO. 8-70-05-001 | |
| c. Project Title: Trafficability of Soils as Related to the Mobility of<br>d. Military Vehicles | 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) |

10. AVAILABILITY/LIMITATION NOTICES

Approved for public release; distribution unlimited.

| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY |
|---|---|
| | Chief of Engineers, DA<br>Washington, D. C. 20315 |

13. ABSTRACT

A 10 day survey was made by a team of geologists, engineers, and engineering aides. Trafficability maps of the selected area were then prepared at a scale of 1:25,000. The analysis described and presented graphically on the maps is concerned solely with the ability of M48 tanks (or vehicles of equivalent characteristics) to operate off roads on natural soil surfaces in the area surveyed. The analysis does not consider the use of special vehicles or improvements of the natural soil surfaces by construction methods.

KEYWORDS: Military bases; Mobility; Tanks (Combat vehicles); Trafficability maps; [Camp Stewart, Ga.; M48 tank]

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Unclassified
Security Classification

M,E

**DOCUMENT CONTROL DATA - R&D**

*(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)*

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|---|---|
| 1. ORIGINATING ACTIVITY (Corporate author)<br>U. S. Army Engineer Waterways Experiment Station<br>Vicksburg, Miss. | 2a. REPORT SECURITY CLASSIFICATION<br>Unclassified<br>2b. GROUP |

3. REPORT TITLE

FIELD TESTS OF NUCLEAR INSTRUMENTS FOR THE MEASUREMENT OF SOIL MOISTURE AND DENSITY

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final report

5. AUTHOR(S) (Last name, first name, initial)

Rush, E. S.
Reinhart, K. G.

| 6. REPORT DATE | 7a. TOTAL NO. OF PAGES | 7b. NO. OF REFS |
|---|---|---|
| March 1955 | 26 | 8 |

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| 8a. CONTRACT OR GRANT NO.<br>b. PROJECT NO. 8-07-05-001,<br>Trafficability of Soils as Related to<br>c. the Mobility of Military Vehicles<br>d. | 9a. ORIGINATOR'S REPORT NUMBER(S)<br>Miscellaneous Paper No. 4-117<br>9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)<br>AD 073 388 |

10. AVAILABILITY/LIMITATION NOTICES

Approved for public release; distribution unlimited

| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY |
|---|---|
| This study was conducted by the USDA Forest Service. | Chief of Engineers, DA<br>Washington, D. C. 20315 |

13. ABSTRACT

This paper presents the results of field testing of nuclear instruments for the purpose of determining if such instruments could be substituted for instruments now in use by the Forest Service to expedite collection of soil moisture and density data in a study being conducted for the Waterways Experiment Station. Additional tests of nuclear instruments are being conducted by the Waterways Experiment Station and Ohio River Division Laboratories, Corps of Engineers, in conjunction with airfield construction. This report, therefore, is to be considered an interim report since future data may warrant revisions of its contents.

KEYWORDS: Field tests; Nuclear equipment; Nuclear methods

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Security Classification

Security Classification M,E

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|---|---|
| 1. ORIGINATING ACTIVITY (Corporate author)<br>U. S. Army Engineer Waterways Experiment Station<br>Vicksburg, Miss. | 2a. REPORT SECURITY CLASSIFICATION<br>Unclassified<br>2b. GROUP |

3. REPORT TITLE

THE DEVELOPMENT OF METHODS FOR PREDICTING SOIL MOISTURE CONTENT; REPORT ON THE FAIRBANKS, ALASKA, EXTENSION

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final report

5. AUTHOR(S) (Last name, first name, initial)

Tobiaski, R. A.
Larson, D. E.

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|---|---|---|
| 6. REPORT DATE<br>July 1955 | 7a. TOTAL NO. OF PAGES<br>154 | 7b. NO. OF REFS<br>0 |

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|---|---|
| 8a. CONTRACT OR GRANT NO.<br>b. PROJECT NO. 8-70-05-001 | 9a. ORIGINATOR'S REPORT NUMBER(S)<br>Miscellaneous Paper No. 4-135 |
| c. Project Title: Trafficability of Soils as Related to the Mobility of<br>d. Military Vehicles | 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)<br>AD 747 826 |

10. AVAILABILITY/LIMITATION NOTICES

Approved for public release; distribution unlimited.

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|---|---|
| 11. SUPPLEMENTARY NOTES<br>U. S. Forest Service cooperated in this study. | 12. SPONSORING MILITARY ACTIVITY<br>Chief of Engineers, DA<br>Washington, D. C. 20315 |

13. ABSTRACT

The U. S. Forest Service, in cooperation with the Waterways Experiment Station, developed methods of predicting soil moisture in the Vicksburg Area. To develop methods for other soil types under a variety of climatic conditions, extension studies were established. This report contains the results of the Fairbanks, Alaska, extension study. Climatic, soil-moisture, and permafrost records were obtained for the period May through September 1954. Field and office procedures used were similar to those previously reported in Technical Memorandum No. 3-331, Report No. 3.

KEYWORDS: Climatological data; Soil data; Soil moisture prediction; Subarctic regions; Trafficability prediction; [Alaska]

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Unclassified
Security Classification

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Security Classification

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| 1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Miss. | 2a. REPORT SECURITY CLASSIFICATION Unclassified |
| | 2b. GROUP |

3. REPORT TITLE

STATISTICAL OCCURRENCE OF SOIL STRENGTH

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final report

5. AUTHOR(S) (Last name, first name, initial)

Knight, S. J.

| 6. REPORT DATE | 7a. TOTAL NO. OF PAGES | 7b. NO. OF REFS |
|---|---|---|
| November 1957 | 6 | 0 |

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| 8a. CONTRACT OR GRANT NO. | 9a. ORIGINATOR'S REPORT NUMBER(S) Miscellaneous Paper No. 4-238 |
| b. PROJECT NO. 8-70-05-100 | |
| c. Project Title: Mobility of the Army | 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) |
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10. AVAILABILITY/LIMITATION NOTICES

Approved for public release; distribution unlimited.

| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY |
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| Published in The Military Engineer, Vol.52, No.346, March-April 1960, Titled "Soil Strength Study." | Chief of Engineers, DA Washington, D. C. 20315 |

13. ABSTRACT

The ability of a soil to support the movement of a military vehicle--its trafficability--can be quantified in terms of rating cone index, a parameter that recognizes not only the strength of a soil in situ but also the strength it will attain under a moving vehicle. The principal influence on the rating cone index of a soil, especially a fine-grained soil, is the amount of water it contains. Waterways Experiment Station studies have shown that in a humid climate the top 12 in. or so of a given fine-grained soil attains a certain maximum soil moisture early in the wet season and maintains this moisture with very little deviation throughout this season. The field maximum offers a practical moisture datum for evaluating the trafficability of various soils. In this report, the distribution of the rating cone index values measured in the 6- to 12-in. layer at 681 sites is summarized. A frequency curve of these data can be used to ascertain the percentage of areas tested that had rating cone indexes below a certain value. By spotting the rating cone index requirement for a given vehicle, the curve also may be used to determine the percentage of area trafficable by the vehicle.

KEYWORDS: Rating cone index; Soil strength; Statistical distributions

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Unclassified

Unclassified

Security Classification

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|---|---|
| 1. ORIGINATING ACTIVITY (Corporate author)<br>U. S. Army Engineer Waterways Experiment Station<br>Vicksburg, Miss. | 2a. REPORT SECURITY CLASSIFICATION<br>Unclassified<br>2b. GROUP |

3. REPORT TITLE

A LIMITED STUDY OF FACTORS THAT AFFECT SOIL STRENGTH

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final report

5. AUTHOR(S) (Last name, first name, initial)

Knight, S. J.
Rush, E. S.

| 6. REPORT DATE | 7a. TOTAL NO. OF PAGES | 7b. NO. OF REFS |
|---|---|---|
| August 1958 | 34 | 0 |

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|---|---|
| 8a. CONTRACT OR GRANT NO.<br>b. PROJECT NO. 8-70-05-100, Mobility of the Army<br>c. Subproject 8-70-05-101, Trafficability of Soils as Related to the<br>d. Mobility of Military Vehicles | 9a. ORIGINATOR'S REPORT NUMBER(S)<br>Miscellaneous Paper No. 4-284<br>9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) |

10. AVAILABILITY/LIMITATION NOTICES

Approved for public release; distribution unlimited.

| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY |
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| | Chief of Engineers, DA<br>Washington, D. C. 20315 |

13. ABSTRACT

To obtain an approximate measure of the gross effects of various natural influences on the strength of a soil, its strength under natural conditions was compared to its strength under similar laboratory conditions of moisture content and density. The test area was located on a lake shore where the soil was very uniform in type and decreased in moisture content with distance from the lake, giving a wide range of moisture and strength conditions. The soil, a heavy clay, was tested for moisture, density, and cone index in its natural state and in the laboratory, and for remolding index in the field. Principal conclusions were that (a) the cone index of a given sample at a given moisture content and density varies with the structure and compaction history of the sample, and (b) compaction effort, difference in water-holding capacity of the soil in situ and after laboratory treatment, and surcharge are the principal factors affecting laboratory density-strength-moisture content relationships.

KEYWORDS: Clays; Field tests; Fine grained soils; Soil density; Soil moisture; Soil property relations; Soil strength; Trafficability; Laboratory tests

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Unclassified

Unclassified

Security Classification

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|---|---|
| 1. ORIGINATING ACTIVITY (Corporate author)<br>U. S. Army Engineer Waterways Experiment Station<br>Vicksburg, Miss. | 2a. REPORT SECURITY CLASSIFICATION<br>Unclassified<br>2b. GROUP |

3. REPORT TITLE

METEOROLOGICAL AND TRAFFICABILITY DATA, U.S.-CANADIAN ARCTIC WEATHER STATION

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final report

5. AUTHOR(S) (Last name, first name, initial)

Rush, E. S.

| | | |
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| 6. REPORT DATE<br>January 1959 | 7a. TOTAL NO. OF PAGES<br>33 | 7b. NO. OF REFS<br>0 |
| 8a. CONTRACT OR GRANT NO.<br>b. PROJECT NO. 8-70-00-000<br>Ground Mobility Research<br>c Subproject 8-70-05-400, Trafficability of Soils as Related to the Mobility<br>d Military Vehicles | 9a. ORIGINATOR'S REPORT NUMBER(S)<br>Miscellaneous Paper No. 4-298<br>9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)<br>AD 756 305 | |

10. AVAILABILITY/LIMITATION NOTICES

Approved for public release; distribution unlimited.

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|---|---|
| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY<br>Chief of Engineers, DA<br>Washington, D. C. 20315 |

13. ABSTRACT

This report presents soil and meteorological data collected during the summer months (June, July, and August) of 1955 at the Arctic weather stations located at Alert and Mould Bay, and during June-September 1954, 1955, and 1956 at Eureka. At each weather station, three test sites were established--one at a low elevation, one at an intermediate elevation, and one at a high elevation. Cone index, moisture content, density, depth to permafrost, and meteorological data were recorded. The data were not sufficient to determine relations between soil moisture and meteorological parameters, but did permit an approximate evaluation of trafficability conditions at the three sites during the summer season.

KEYWORDS: Arctic regions; Field tests; Meterological data; Soil property relations; Trafficability, Trafficability data; [Canada; Northwest Territory]

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Security Classification

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|---|---|
| 1. ORIGINATING ACTIVITY (Corporate author)<br>U. S. Army Engineer Waterways Experiment Station<br>Vicksburg, Miss. | 2a. REPORT SECURITY CLASSIFICATION<br>Unclassified<br>2b. GROUP |

3. REPORT TITLE

PREDICTION OF SOIL MOISTURE FROM SOIL AND WEATHER RECORDS

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final report

5. AUTHOR(S) (Last name, first name, initial)

Burke, H. D.
Turnbull, W. J.

| 6. REPORT DATE | 7a. TOTAL NO. OF PAGES | 7b. NO. OF REFS |
|---|---|---|
| April 1959 | 11 | 0 |

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| 8a. CONTRACT OR GRANT NO. | 9a. ORIGINATOR'S REPORT NUMBER(S) |
| b. PROJECT NO. | Miscellaneous Paper No. 4-338 |
| c. Subproject No. 8-70-05-400, Trafficability of Soils as Related to<br>d. Mobility of Military Vehicles | 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)<br>AD A006 496 |

10. AVAILABILITY/LIMITATION NOTICES

Approved for public release; distribution unlimited.

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| 11. SUPPLEMENTARY NOTES<br>Presented at Int Assn of Hydrology Symposium on Forests and Waters, Kassel, Germany, 8-11 September 1959, Public. No.48 de A.I.H.S. | 12. SPONSORING MILITARY ACTIVITY<br>Chief of Engineers, DA<br>Washington, D. C. 20315 |

13. ABSTRACT

As part of a study to develop means of estimating the ability of soils to permit vehicular traffic, a method was developed for predicting the moisture content of soils. This paper summarizes the relations found necessary for the prediction of moisture in the surface foot of soil and discusses the accuracy with which these predictions have been made.

KEYWORDS: Meteorological data; Soil moisture prediction; Soil property relations; State-of-the-art studies

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Security Classification

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|---|---|
| 1. ORIGINATING ACTIVITY (Corporate author)<br>U. S. Army Engineer Waterways Experiment Station<br>Vicksburg, Miss. | 2a. REPORT SECURITY CLASSIFICATION<br>Unclassified<br>2b. GROUP |

3. REPORT TITLE

TRAFFICABILITY PREDICTIONS IN TROPICAL SOILS; FOUR SOILS IN THE PANAMA CANAL ZONE

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Report 1 in a series.

5. AUTHOR(S) (Last name, first name, initial)

Rula, A. A.
Rush, E. S.

| 6. REPORT DATE | 7a. TOTAL NO. OF PAGES | 7b. NO. OF REFS |
|---|---|---|
| September 1959 | 65 | 0 |

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|---|---|
| 8a. CONTRACT OR GRANT NO.<br>b. PROJECT NO.<br>c. Subproject 8-70-05-400, Trafficability of Soils as Related to the Mobility of Military Vehicles | 9a. ORIGINATOR'S REPORT NUMBER(S)<br>Miscellaneous Paper No. 4-355<br>Report 1<br>9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)<br>AD A006 520 |

10. AVAILABILITY/LIMITATION NOTICES

Approved for public release; distribution unlimited.

| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY |
|---|---|
| | Chief of Engineers, DA<br>Washington, D. C. 20315 |

13. ABSTRACT

Four sites in the Canal Zone were studied to determine whether the techniques used to develop a soil moisture prediction system for temperate-climate soils could be successfully applied to tropical-climate soils. Soil moisture and strength data were collected weekly at the sites, and climatological data daily, for 18 months. Actual soil-moisture contents on the starting date were used to start the predictions. Comparison of predicted and measured soil moistures indicate that: (a) the techniques used to develop a soil-moisture prediction system for temperate climate could be successfully applied to tropical soils: (b) the average soil-moisture predictions developed from temperate climate data can be used with some success on tropical soils; (c) the quality of moisture content-strength relations for tropical soils is considerably lower than similar relations derived for temperate-climate soils. Conclusions regarding trafficability of the region during the wet season were: (a) upland soils are generally trafficable though wheeled vehicles may fail to climb slopes because of slipperiness; (b) lowland soils are generally trafficable only for low-ground-pressure tracked vehicles.

KEYWORDS: Soil moisture prediction; Trafficability prediction; Tropical regions; [Panama Canal Zone]

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Unclassified

Security Classification

M,E

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| 1. ORIGINATING ACTIVITY (Corporate author)<br>U. S. Army Engineer Waterways Experiment Station<br>Vicksburg, Miss. | 2a. REPORT SECURITY CLASSIFICATION<br>Unclassified<br>2b. GROUP |

3. REPORT TITLE

TRAFFICABILITY PREDICTIONS IN TROPICAL SOILS; PUERTO RICO STUDY

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Report 2 in a series

5. AUTHOR(S) (Last name, first name, initial)

Tobiaski, R. A.
Bassett, J. R.
Rush, E. S.

| 6. REPORT DATE | 7a. TOTAL NO. OF PAGES | 7b. NO. OF REFS |
|---|---|---|
| February 1960 | 116 | 19 |

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|---|---|
| 8a. CONTRACT OR GRANT NO.<br>b. PROJECT NO. 8-70-00-000<br>Ground Mobility Research<br>c. Subproject 8-70-05-400, Trafficability of Soils as Related to the Mobility of<br>d. Military Vehicles | 9a. ORIGINATOR'S REPORT NUMBER(S)<br>Miscellaneous Paper No. 4-355<br>Report 2<br>9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)<br>AD A032 705 |

10. AVAILABILITY/LIMITATION NOTICES

Approved for public release; distribution unlimited.

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|---|---|
| 11. SUPPLEMENTARY NOTES<br>U. S. Forest Service collaborated in this study. | 12. SPONSORING MILITARY ACTIVITY<br>Chief of Engineers, DA<br>Washington, D. C. 20315 |

13. ABSTRACT

The soil-moisture prediction method previously found applicable to U. S. sites was found applicable also to 8 Puerto Rico prediction development sites. Predictions based on data collected at these 9 sites were reasonably accurate when applied to 22 other sites in Puerto Rico; predictions based on U. S.-derived data were somewhat less accurate, principally because soil-moisture depletion rates in Puerto Rico are considerably different from those in the U. S. It was found that (a) Puerto Rico soils do not lose moisture as fast as U. S. soils, and the rate of loss seems to be unaffected by season; and (b) the average rate of daily moisture depletion in the surface to 12-in. layer of Puerto Rico soils is about 1/2 the average summer rate and about equal to the spring-autumn rate in humid climates of the U. S. Soil-moisture content correlated fairly well with both cone index and rating cone index but poorly with remolding index.

KEYWORDS: Soil moisture prediction; Trafficability prediction; Tropical regions; [Puerto Rico]

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Security Classification

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*(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)*

1. ORIGINATING ACTIVITY (Corporate author)
U. S. Army Engineer Waterways Experiment Station
Vicksburg, Mississippi

2a. REPORT SECURITY CLASSIFICATION
Unclassified

2b. GROUP

3. REPORT TITLE
TRAFFICABILITY PREDICTIONS IN TROPICAL SOILS; PANAMA STUDY NO. 2 (OCTOBER 1961 - SEPTEMBER 1963)

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
Report 3 of a series

5. AUTHOR(S) (Last name, first name, initial)
McDaniel, Alvin R.

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11. SUPPLEMENTARY NOTES

12. SPONSORING MILITARY ACTIVITY
U. S. Army Materiel Command
Washington, D. C. 20315

13. ABSTRACT

Soil trafficability studies have shown that the strength of a soil is of major importance to vehicle mobility and varies principally with soil moisture; therefore, a means of predicting moisture content of a soil is essential to the forecasting of soil trafficability. The U. S. Army Engineer Waterways Experiment Station soil-moisture prediction method for U. S. soils was applied to sites located in the Panama Canal Zone to determine whether the method was applicable for the prediction of moisture content of tropical soils. Factors necessary for the predictions were obtained at specific sites, and analysis of data shows that the method is applicable to Panama soils. Groundwater did not have an appreciable influence on soil-moisture depletion since drainage from the 0- to 12-in. layer was rapid. An analysis of strength data showed a highly significant relation between moisture content and cone index, and a lesser degree of significance between moisture content and rating cone index. No relation was found between moisture content and remolding index. On the basis of rating cone index, the trafficability of the residual soils was considered good. Trafficability of the alluvial marshland soils was considered good during the dry season and poor during the wet season.

KEYWORDS: Soil-moisture prediction; Trafficability prediction; Tropical regions; [Panama Canal Zone]

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| 1. ORIGINATING ACTIVITY (Corporate author)<br>U. S. Army Engineer Waterways Experiment Station<br>Vicksburg, Miss. 39180 | 2a. REPORT SECURITY CLASSIFICATION<br>Unclassified<br>2b. GROUP |

3. REPORT TITLE

TRAFFICABILITY PREDICTIONS IN TROPICAL SOILS; COLOMBIA STUDY (JULY 1962-JULY 1963)

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Report 4 of series

5. AUTHOR(S) (First name, middle initial, last name)

Alvin R. McDaniel

| 6. REPORT DATE | 7a. TOTAL NO. OF PAGES | 7b. NO. OF REFS |
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| November 1967 | 75 | 9 |

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| 8a. CONTRACT OR GRANT NO.<br>b. PROJECT NO. 1-V-0-21701-A-046,<br>Trafficability and Mobility Research<br>c. Task -02, Surface Mobility<br>d. | 9a. ORIGINATOR'S REPORT NUMBER(S)<br>Miscellaneous Paper No. 4-355<br>Report 4<br>9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)<br>AD 824 734L |

10. DISTRIBUTION STATEMENT

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| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY |
|---|---|
| | U. S. Army Materiel Command<br>Washington, D. C. 20315 |

13. ABSTRACT

The U. S. Army Engineer Waterways Experiment Station (WES) soil-moisture prediction method for United States soils was applied to sites in Colombia to determine whether the method was applicable for the prediction of moisture content of tropical soils.

Data were collected at four prediction development sites in the subhumid climate of the "Sabana de Bogota" located in the Andean Mountain ranges of Colombia. Changes in soil-moisture content, soil density, and soil strength with changes in weather conditions were investigated periodically for one year.

These data were analyzed and used to predict daily soil-moisture content and to establish the relation between soil moisture content and soil strength. The results show that the WES soil-moisture prediction method is applicable to prediction of soil-moisture content at the four sites in Colombia. Data were of sufficient quantity to establish soil-moisture depletion curves for each site but not of sufficient quantity to establish accretion relations. Relations were established between soil-moisture content and soil strength at all sites. Trafficability of the soils tested, as indicated by rating cone index, was good even when the soils were at maximum moisture content.

Basic data and photographs for each test site are included as Appendix A.

KEYWORDS: Soil moisture prediction; Trafficability prediction; Tropical regions; [Colombia, S.A.]

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| 1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Miss. 39180 | 2a. REPORT SECURITY CLASSIFICATION Unclassified |
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3. REPORT TITLE

TRAFFICABILITY PREDICTIONS IN TROPICAL SOILS; Report 5, COSTA RICA STUDY NO. 1 (JANUARY 1963 - JANUARY 1965)

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Report 5 of a series

5. AUTHOR(S) (First name, middle initial, last name)

Alvin R. McDaniel

| 6. REPORT DATE | 7a. TOTAL NO. OF PAGES | 7b. NO. OF REFS |
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| December 1967 | 99 | 8 |

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| 8a. CONTRACT OR GRANT NO. | 9a. ORIGINATOR'S REPORT NUMBER(S) Miscellaneous Paper No. 4-355 Report 5 |
| b. PROJECT NO. 1-V -0-21701-A-046, Trafficability and Mobility Research c. Task-02, Surface Mobility d. | 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) AD 824 882L |

10. DISTRIBUTION STATEMENT

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| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY |
|---|---|
| | U. S. Army Materiel Command Washington, D. C. |

13. ABSTRACT

Soil trafficability studies have shown that the strength of a soil is of major importance to vehicle mobility and varies principally with soil moisture; therefore, a means of predicting moisture content of a soil is essential to the forecasting of soil trafficability. The U. S. Army Engineer Waterways Experiment Station (WES) soil-moisture prediction method for United States soils was applied to sites in Costa Rica to determine whether the method was applicable for the predition of moisture content of tropical soils. Data necessary for the predictions were collected on five sites in the Premontane wet climate of the Reventazón Valley at Turrialba, Costa Rica. Changes in soil moisture content, density, strength, and remolding strength with changes in weather conditions were investigated at regular intervals for 25 months. These data were analyzed and used to predict soil-moisture content and to establish the relation between moisture content and soil strength. The analysis shows that the WES method is applicable to prediction of soil-moisture content at the five sites in Costa Rica. Groundwater did not have an appreciable influence on soil moisture depletion since drainage from the 0- to 12-in. (0- to 30.5-cm) soil layer was related directly to rainfall. Topography was shown to influence soil-moisture content to some degree. Analysis of strength data showed a highly significant relation between soil strength and moisture content. On the basis of rating cone index, the trafficability of the soils was considered poor during the wet season and good during the latter part of the dry season. Basic data and photographs for each test site are included as Appendix A.

KEYWORDS: Soil moisture prediction; Trafficability prediction; Tropical regions; [Costa Rica]

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Unclassified

Security Classification

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| 1. ORIGINATING ACTIVITY (Corporate author)<br>U. S. Army Engineer Waterways Experiment Station<br>Vicksburg, Mississippi | 2a. REPORT SECURITY CLASSIFICATION<br>Unclassified<br>2b. GROUP |

3. REPORT TITLE

TRAFFICABILITY PREDICTIONS IN TROPICAL SOILS; PUERTO RICO STUDY NO. 2 (MARCH 1962 - NOVEMBER 1963)

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Report 6 in a series

5. AUTHOR(S) (First name, middle initial, last name)

James G. Kennedy
Thomas E. Hicks

| 6. REPORT DATE | 7a. TOTAL NO. OF PAGES | 7b. NO. OF REFS |
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| November 1968 | 263 | 38 |

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| 8a. CONTRACT OR GRANT NO. | 9a. ORIGINATOR'S REPORT NUMBER(S) |
| b. PROJECT NO. 1V021701A046 | Miscellaneous Paper No. 4-355, Report 6 |
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10. DISTRIBUTION STATEMENT

Approved for public release; distribution unlimited.

| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY |
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| | U. S. Army Materiel Command<br>Washington, D. C. |

13. ABSTRACT

The soil moisture prediction method for soils in the U. S. was previously applied to eight sites in Puerto Rico and was found applicable to those soils. The study reported herein was to determine whether the prediction method was applicable, without major modifications, to other sites in Puerto Rico. Factors necessary for the predictions were obtained at specific sites, and analysis of data shows that the method is applicable to Puerto Rican soils; however, it was necessary to modify the method when the groundwater table was within the surface foot for prolonged periods. Groundwater did not have an appreciable influence on soil moisture depletion when the water table occurred within the surface foot for a short period, since drainage from this layer was rapid. At sites where water tables existed within the surface foot for prolonged periods, the derived depletion curves were not applicable. An analysis of strength data showed a highly significant relation between moisture content and cone index, and a lesser degree of significance between moisture content and rating cone index. Only 3 of 29 test sites showed any relation between moisture content and remolding index. On the basis of rating cone index, it appears that sites within the playas and alluvial plains of Puerto Rico may present trafficability problems throughout the year. Other areas with good drainage and seasonal rainfall may not be trafficability problem areas except during the extremely wet period. Basic data and photographs for each test site are included as Appendix A.

KEYWORDS: Soil moisture prediction; Trafficability prediction; Tropical regions; [Puerto Rico]

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| 1. ORIGINATING ACTIVITY (Corporate author)<br>U. S. Army Engineer Waterways Experiment Station<br>Vicksburg, Miss. | 2a. REPORT SECURITY CLASSIFICATION<br>Unclassified<br>2b. GROUP |
| 3. REPORT TITLE<br>TRAFFICABILITY PREDICTIONS IN TROPICAL SOILS; Report 7, HAWAII STUDY | |
| 4. DESCRIPTIVE NOTES (Type of report and inclusive dates)<br>Report 7 of a series | |
| 5. AUTHOR(S) (First name, middle initial, last name)<br>C. A. Carlson<br>W. P. Bohnert, Jr.<br>M. P. Meyer | |
| 6. REPORT DATE<br>November 1970 | 7a. TOTAL NO. OF PAGES: 113 — 7b. NO. OF REFS: 9 |
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| 10. DISTRIBUTION STATEMENT<br>Approved for public release; distribution unlimited. | |
| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY<br>U. S. Army Materiel Command<br>Washington, D. C. |

13. ABSTRACT

Soil trafficability studies have shown that the strength of a soil is of major importance to vehicle mobility and that strength varies principally with soil moisture; therefore, a means of predicting moisture content of a soil and knowledge of the relation between soil moisture and strength are essential to the forecasting of soil trafficability. The U. S. Army Engineer Waterways Experiment Station soil-moisture prediction method was applied to sites in Hawaii to determine whether the method was valid for the prediction of moisture content of these tropical soils. Data were collected from January 1960 to June 1961 at 34 sites, on three Hawaiian islands, representing the major soils, weather regimes, terrains, and land uses in Hawaii. The data from 11 sites were analyzed and used to predict daily soil moisture contents, and data from all sites were used to determine the relations between moisture content and soil strength. The moisture prediction method was found valid. Relations were found between moisture content and strength, but at many sites they were poor due to the variability of the soil. In terms of rating cone index, the trafficability of the upland allophane clays was poor throughout the year. Trafficability was periodically poor following high rainfalls on an upland soil with a perched water table and on soils from alluvium in the lowlands. Other upland soils had good trafficability throughout the year. Basic data are included as Appendix A.

KEYWORDS: Soil moisture prediction; Trafficability prediction; Tropical regions; [Hawaii]

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1. ORIGINATING ACTIVITY *(Corporate author)*

U. S. Army Engineer Waterways Experiment Station
Vicksburg, Mississippi

2a. REPORT SECURITY CLASSIFICATION

Unclassified

2b. GROUP

3. REPORT TITLE

TRAFFICABILITY PREDICTIONS IN TROPICAL SOILS; Report 8, COSTA RICA STUDY NO. 2 (JANUARY 1964-SEPTEMBER 1965)

4. DESCRIPTIVE NOTES *(Type of report and inclusive dates)*

Report 8 of a series

5. AUTHOR(S) *(First name, middle initial, last name)*

Alvin R. McDaniel
Margaret H. Smith

| 6. REPORT DATE | 7a. TOTAL NO. OF PAGES | 7b. NO. OF REFS |
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8a. CONTRACT OR GRANT NO.

b. PROJECT NO. 1-T-0-62103-A-046

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9a. ORIGINATOR'S REPORT NUMBER(S)

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9b. OTHER REPORT NO(S) *(Any other numbers that may be assigned this report)*

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10. DISTRIBUTION STATEMENT

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11. SUPPLEMENTARY NOTES

12. SPONSORING MILITARY ACTIVITY

U. S. Army Materiel Command
Washington, D. C.

13. ABSTRACT

A U. S. Army Engineer Waterways Experiment Station (WES) soil moisture prediction method was modified to permit predictions to be made with a limited amount of information from a site. Using this method of prediction and precipitation records from weather stations, a system of mapping soil moisture contents throughout Costa Rica is presented. Using these maps, soil moisture contents can be determined for any site with knowledge of only the field-minimum and field-maximum moisture contents of the soil. Soil moisture predictions made for 65 Costa Rica sites using the modified method compare favorably with predictions made in the United States using the WES soil moisture prediction method. Soil strengths, in terms of cone index, were predicted using a general Costa Rica soil moisture-soil strength relation and using specific site relations derived by simple linear regression and reduced major axis regression techniques. When predictions with the general Costa Rica relation were compared with measured cone indexes they fell far short of the accuracy of the predictions using the other two prediction techniques. Therefore, this simplified method was abandoned as a reliable prediction method, and predictions of cone index and rating cone index using only the simple linear regression relations are presented.

KEYWORDS: Soil moisture prediction; Trafficability prediction; Tropical regions; [Costa Rica]

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| 1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Miss. | 2a. REPORT SECURITY CLASSIFICATION Unclassified |
| | 2b. GROUP |

3. REPORT TITLE

LABORATORY TESTS OF LIQUID NITROGEN SOIL-MOISTURE SAMPLERS

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final report

5. AUTHOR(S) (Last name, first name, initial)

Burke, H. D.
Krumbach, A. W.
Rush, E. S.

| 6. REPORT DATE | 7a. TOTAL NO. OF PAGES | 7b. NO. OF REFS |
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| January 1960 | 35 | 9 |

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| 8a. CONTRACT OR GRANT NO. | 9a. ORIGINATOR'S REPORT NUMBER(S) |
| b. PROJECT NO. 8-70-00-000 Ground Mobility Research | Miscellaneous Paper No. 4-371 |
| c. Subproject 8-70-05-400, Trafficability of Soils as Related to the Mobility of d. Military Vehicles | 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) AD 756 311 |

10. AVAILABILITY/LIMITATION NOTICES

Approved for public release; distribution unlimited.

| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY |
|---|---|
| U. S. Forest Service collaborated in this study. | Chief of Engineers, DA Washington, D. C. 20315 |

13. ABSTRACT

This limited laboratory study was made to determine whether a method for quick-freezing and extracting soil samples provided more accurate determination of moisture content than did mechanical samplers, particularly for very wet soils. The quick-freezing was accomplished with liquid nitrogen poured into a hollow probe inserted in the soil. In tests on soils whose moisture contents ranged to well above the liquid limit, it was determined that accuracy with the quick-freeze method was almost as good as with the mechanical samplers. This conclusion was based mainly on reproducibility of results. The liquid nitrogen probe was used over a range of soil-moisture contents, the sampling of which normally requires use of three types of mechanical samplers.

KEYWORDS: Laboratory tests; Liquid nitrogen; Soil moisture measuring devices; Soil samplers

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| 1. ORIGINATING ACTIVITY (Corporate author)<br>U. S. Army Engineer Waterways Experiment Station<br>Vicksburg, Mississippi | 2a. REPORT SECURITY CLASSIFICATION<br>Unclassified<br>2b. GROUP |

3. REPORT TITLE
PHYSICAL COMPONENTS OF THE SHEAR STRENGTH OF SATURATED CLAYS

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

5. AUTHOR(S) (First name, middle initial, last name)

H. Juul Hvorslev

| 6. REPORT DATE | 7a. TOTAL NO. OF PAGES | 7b. NO. OF REFS |
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| January 1961 | 120 | |

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| 8a. CONTRACT OR GRANT NO. | 9a. ORIGINATOR'S REPORT NUMBER(S) |
| b. PROJECT NO. | Miscellaneous Paper No. 3-428 |
| c. | 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) |
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10. DISTRIBUTION STATEMENT

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| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY |
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| Published in Proceedings of ASCE Research Conference on Shear Strength of Cohesive Soils, Univ. of Colorado, Boulder, Colo., June 1960 | Chief of Engineers, DA<br>Washington, D. C. 20315 |

13. ABSTRACT

The paper deals primarily with the physical components of the shear strength of remolded, saturated clays and with the various factors which influence these components. The results of subsequent research by others are taken into consideration and summarized when appropriate, but the paper is not a complete review of the very extensive and important research on shear strength of saturated clays performed during the last twenty years. The sources of error in the tests performed by the writer are discussed, and emphasis is placed on clarification of the assumptions and limitations relating to the conclusions and formerly proposed criteria for the shear strength of saturated clays.

KEYWORDS: Clays; Saturated soils; Shear strength (Soils); Soil strength

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| **1. ORIGINATING ACTIVITY (Corporate author)**<br>U. S. Army Engineer Waterways Experiment Station<br>Vicksburg, Miss. | **2a. REPORT SECURITY CLASSIFICATION**<br>Unclassified<br>**2b. GROUP** |

**3. REPORT TITLE**

SOIL TRAFFICABILITY CLASSIFICATION SCHEME

**4. DESCRIPTIVE NOTES (Type of report and inclusive dates)**

Final report

**5. AUTHOR(S) (Last name, first name, initial)**

Knight, S. J.
Meyer, M. P.

| **6. REPORT DATE** | **7a. TOTAL NO. OF PAGES** | **7b. NO. OF REFS** |
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| **8a. CONTRACT OR GRANT NO.**<br>**b. PROJECT NO.** 8S70-05-001<br>Trafficability and Mobility Research<br>**c.** Subproject 8S70-05-001-02, Surface Mobility<br>**d.** | **9a. ORIGINATOR'S REPORT NUMBER(S)**<br>Miscellaneous Paper No. 4-442<br>**9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)** |

**10. AVAILABILITY/LIMITATION NOTICES**

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| **11. SUPPLEMENTARY NOTES** This paper presented at the meeting of the International Society of Terrain-Vehicle Systems in Turin, Italy, June 1961. | **12. SPONSORING MILITARY ACTIVITY**<br>Chief of Engineers, DA<br>Washington, D. C. 20315 |

**13. ABSTRACT**

A study was made of pertinent soil trafficability data collected during the wet season at more than 1300 sites located principally in humid-temperate regions of the United States. The soils were identified according to the Unified Soil Classification System and U. S. Department of Agriculture textural classification system, topographic position, and two general levels of wetness. A scheme for classifying soils according to their trafficability was developed. The scheme lists the soil types in order of decreasing strength under each of four topography-general wetness level categories, and shows the probability of successful passage on each soil for vehicles with known soil strength requirements. This scheme permits the estimation of the probability of a successful operation under given soil type, topography, and general wetness level conditions. Given the choice of several routes and vehicles, the determination can be made of the vehicles with the best chances of success over a given route or which route is best for given vehicles.

KEYWORDS: Soil strength; Statistical distributions; Trafficability classification

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| 1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi | 2a. REPORT SECURITY CLASSIFICATION Unclassified |
| | 2b. GROUP |

3. REPORT TITLE

CLASSIFICATION OF TERRAIN FOR MOBILITY PURPOSES

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

5. AUTHOR(S) (First name, middle initial, last name)

J. R. VanLopik, J. R. Compton

| 6. REPORT DATE | 7a. TOTAL NO. OF PAGES | 7b. NO. OF REFS |
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| August 1961 | 24 | 17 |

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| 8a. CONTRACT OR GRANT NO. | 9a. ORIGINATOR'S REPORT NUMBER(S) |
| b. PROJECT NO. | Miscellaneous Paper No. 4-444 |
| c. | 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) |
| d. | AD 666 222 |

10. DISTRIBUTION STATEMENT

Approved for public release; distribution unlimited.

| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY |
|---|---|
| Presented at First International Conference on the Mechanics of Soil-Vehicle Systems Turin, Italy, June 1961 | Office, Chief of Engineers, Department of the Army, Washington, D. C. |

13. ABSTRACT

The principal elements of landscape that affect the capability of vehicles to travel cross country are topography, surface composition and consistency, vegetative cover, and hydrography. These elements combined in various ways tend to deny and slow movement, decrease efficiency, increase maintenance, increase driver fatigue, and control direction. This paper presents a few techniques which have been developed to classify and map terrain elements in objective and fairly quantitative terms. Techniques of this type may eventually permit valid evaluations of trafficability and mobility characteristics of specific areas.

KEYWORDS: Mobility; Terrain classification; Terrain factors; Terrain mapping

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| 1. ORIGINATING ACTIVITY (Corporate author)<br>U. S. Army Engineer Waterways Experiment Station<br>Vicksburg, Miss. | 2a. REPORT SECURITY CLASSIFICATION<br>Unclassified<br>2b. GROUP |

3. REPORT TITLE

COMPARISON OF TRAFFICABILITY OF MUSKEG WITH TRAFFICABILITY OF OTHER SOFT SOILS

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final report

5. AUTHOR(S) (Last name, first name, initial)

Rula, A. A.

| 6. REPORT DATE | 7a. TOTAL NO. OF PAGES | 7b. NO. OF REFS |
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10. AVAILABILITY/LIMITATION NOTICES

Approved for public release; distribution unlimited.

| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY |
|---|---|
| Presented at Second Meeting of the Tripartite Working Group on Ground Mobility, Canada, September 1960. | Chief of Engineers, DA<br>Washington, D. C. 20315 |

13. ABSTRACT

In this paper, the trafficability of muskeg is discussed in some detail and compared with that of other soft terrains, namely, muck, lacustrine, deltaic, and tidal land forms. Trafficability is compared on the basis of the respective strength profiles in the various soils and, where appropriate, on the basis of rating cone index. Other trafficability factors, such as slope, stickiness, and sliperiness, are discussed where applicable. The final assessment of the trafficability of soft terrain is made on the basis of the vehicles that this terrain will support.

KEYWORDS: Muskeg; Soft soils; Soil strength; Trafficability

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| 1. ORIGINATING ACTIVITY (Corporate author)<br>U. S. Army Engineer Waterways Experiment Station<br>Vicksburg, Miss. | 2a. REPORT SECURITY CLASSIFICATION<br>Unclassified<br>2b. GROUP |

3. REPORT TITLE

PROPERTIES OF SURFACE SOILS IN THE WET SEASON

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final report

5. AUTHOR(S) (Last name, first name, initial)

Turnbull, W. J.
Knight, S. J.

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10. AVAILABILITY/LIMITATION NOTICES

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| 11. SUPPLEMENTARY NOTES Presented at Fifth Int Conf on Soil Mechanics and Foundation Engineering, Paris, France, 17-22 July 1961; Published in Proceedings | 12. SPONSORING MILITARY ACTIVITY<br>Chief of Engineers, DA<br>Washington, D. C. 20315 |

13. ABSTRACT

Results are summarized of tests of moisture content, density, and strength of surface soils at several hundred sites in humid-climate areas of the United States. A first-order approximation of values of these properties on the basis of soil texture is indicated by a graphic analysis.

KEYWORDS: Soil property measurements; Soil texture; Statistical analysis; Temperate regions; Trafficability data

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| U. S. Army Engineer Waterways Experiment Station<br>Vicksburg, Miss. | Unclassified |
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**3. REPORT TITLE**

SOME FACTORS AFFECTING MOISTURE CONTENT-DENSITY-CONE INDEX RELATIONS

**4. DESCRIPTIVE NOTES (Type of report and inclusive dates)**

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**5. AUTHOR(S) (Last name, first name, initial)**

Knight, S. J.

| 6. REPORT DATE | 7a. TOTAL NO. OF PAGES | 7b. NO. OF REFS |
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| 8a. CONTRACT OR GRANT NO. | 9a. ORIGINATOR'S REPORT NUMBER(S) |
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| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY |
|---|---|
| | Chief of Engineers, DA<br>Washington, D. C. 20315 |

**13. ABSTRACT**


This paper presents the results of a study conducted to determine what effect certain methods of handling soil samples before they are compacted and tested would have on moisture-density-cone index relations, if the compaction technique was kept constant. Four techniques of soil preparation, identified as re-use, Blakeslee mixing, Bonnot mixing, and air-dried, were used on three soils--a low-plasticity soil, a medium-plasticity soil, and a high-plasticity soil. Density-moisture content and cone index-moisture content curves were developed for moisture contents higher than optimum using the different soil-preparation techniques. These curves were compared with reference curves developed using preparation techniques normally used in trafficability studies. Since the density-cone index-moisture relations that resulted from the different preparations of the soils often differed significantly from the reference relations, it was recommended that the laboratory techniques currently used (i.e. those used in determining the reference relations) be continued in trafficability studies and that additional comparisons of field and laboratory relations be made, where feasible, with a view toward eventual development of criteria for extrapolating rating cone index-moisture content curves from laboratory cone index-moisture content curves.



KEYWORDS: Laboratory tests; Soil density; Soil moisture; Soil property relations; Soil strength; Trafficability


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3. REPORT TITLE

A TECHNIQUE FOR MAPPING TRAFFICABILITY

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final report

5. AUTHOR(S) (Last name, first name, initial)

Knight, S. J.
Meyer, M. P.

| 6. REPORT DATE | 7a. TOTAL NO. OF PAGES | 7b. NO. OF REFS |
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| 8a. CONTRACT OR GRANT NO.<br>b. PROJECT NO. 8S70-05-001<br>Trafficability and Mobility Research<br>c. Subproject No. -02,<br>Surface Mobility (Trafficability)<br>d. | 9a. ORIGINATOR'S REPORT NUMBER(S)<br>Miscellaneous Paper No. 4-461<br>9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)<br>AD 754 334 |

10. AVAILABILITY/LIMITATION NOTICES

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| 11. SUPPLEMENTARY NOTES<br>This paper appeared in The Military Engineer, May-June 1962, Vol.54, No.359. | 12. SPONSORING MILITARY ACTIVITY<br>Chief of Engineers, DA<br>Washington, D. C. 20315 |

13. ABSTRACT

This study provides a technique for portraying trafficability, developed by the Trafficability Section, WES. The method depends primarily on agricultural soils data (soil series and type) readily available in published form. The analysis is limited to general topography, soils, and vegetation in an area comprising Alabama and Georgia. The basic soil information is interpreted in terms of eight trafficability classes. Vehicle mobility of the M48 tank is described in terms of passable, doubtful, and impracticable under soil-moisture conditions including dry-season average conditions, wet-season average conditions, and maximum moisture conditions.

KEYWORDS: Trafficability classification; Trafficability mapping; [Alabama; Georgia]

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| 1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station | 2a. REPORT SECURITY CLASSIFICATION Unclassified; 2b. GROUP |

3. REPORT TITLE

PREDICTING SOIL-MOISTURE DISTRIBUTION IN AREAS OF SEASONAL FROST, FEASIBILITY STUDY

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

5. AUTHOR(S) (First name, middle initial, last name)

J. R. VanLopik, Charles R. Kolb

| 6. REPORT DATE | 7a. TOTAL NO. OF PAGES | 7b. NO. OF REFS |
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| b. PROJECT NO. | Miscellaneous Paper No. 3-482 |
| c. | 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) |
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10. DISTRIBUTION STATEMENT

Approved for public release; distribution unlimited.

| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY |
|---|---|
| | U. S. Army Engineer Division, New England |

13. ABSTRACT

This report reviews the pertinent factors involved in predicting soil-moisture distribution patterns in areas of seasonal frost. Although the factors affecting such prediction methods are varied and complexly interrelated, it is concluded that useful prediction methods can be developed. It is recommended that a preliminary phase of the investigation be undertaken involving (a) the mapping of important soils-hydrologic conditions in the frost-susceptible region of North America as a guide for intelligently selecting sites for further field investigation; (b) the use of field sites, for which considerable data are already available, for detailed study of frost phenomena; and (c) a laboratory experiment to isolate variables affecting moisture and frost distribution under controlled conditions. A paper on prediction of soil moisture from soil and weather records is included herein as Appendix A.

KEYWORDS: Feasibility studies; Freeze-thaw; Frost susceptible soils; Soil moisture prediction; Temperate regions; Subarctic regions

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U. S. Army Engineer Waterways Experiment Station
Vicksburg, Mississippi

2a. REPORT SECURITY CLASSIFICATION
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3. REPORT TITLE
CLASSIFICATION OF LANDSCAPE GEOMETRY FOR MILITARY PURPOSES

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
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5. AUTHOR(S) (First name, middle initial, last name)
Charles R. Kolb

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9a. ORIGINATOR'S REPORT NUMBER(S)
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9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)
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11. SUPPLEMENTARY NOTES Published in Proceedings of the Army Science Conference, 20-22 Jun 62, U. S. Military Academy, Vol.1, Aug 1962, pp.370-391.

12. SPONSORING MILITARY ACTIVITY
Office, Chief of Engineers
Department of the Army
Washington, D. C.

13. ABSTRACT
A method of classifying landscape based on relief, slope, slope occurrence, and plan-profile is presented. The interrelation of these parameters in landscape definition, modification in definition due to scale difference, and synthesis of these parameters in a single semiquantitative landscape symbolization are discussed. Landscape geometry classification is limited to terrain exhibiting more than 10 ft of relief. Terrain features exhibiting less than 10 ft of relief are classified as surface roughness or microrelief. The goal has been to develop as complete a landscape geometry definition as possible within as simple a framework as possible.

KEYWORDS: Surface geometry classification; Surface geometry factors; Terrain classification

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3. REPORT TITLE

DOCUMENTATION OF CONDITIONS ATTENDANT TO ARMY TACTICAL MOBILITY REQUIREMENTS (HOWZE) BOARD TESTING

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

5. AUTHOR(S) (First name, middle initial, last name)

R. G. Ahlvin and E. E. Garrett

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| 6. REPORT DATE<br>September 1962 | 7a. TOTAL NO. OF PAGES<br>30 | 7b. NO. OF REFS |
| 8a. CONTRACT OR GRANT NO.<br>b. PROJECT NO.<br>c.<br>d. | 9a. ORIGINATOR'S REPORT NUMBER(S)<br>Miscellaneous Paper No. 4-528<br>9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)<br>AD 744 213 | |

10. DISTRIBUTION STATEMENT

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| 11. SUPPLEMENTARY NOTES<br>This document is a Memorandum for Record | 12. SPONSORING MILITARY ACTIVITY<br>Office, Chief of Engineers<br>Department of the Army<br>Washington, D. C. |

13. ABSTRACT

A documentation of environmental (vegetation, macrogeometry and microgeometry) and related conditions at tests involving engineer effort for items and at places as follows: (a) air-mobile engineer support (Ft. Bragg); (b) air-mobile refueling task force (Ft. Bragg); (c) bomb-crater repair in airstrips (Ft. Bragg and Mackall Field); (d) landing strip construction (Ft. Stewart, Ga.); (e) explosive preparation of helicopter landing sites (Ft. Bragg); and (f) multiple C-130 landings at Falcon airstrip (Ft. Bragg). Testing was conducted from May to July 1962.

KEYWORDS: Airfield construction; Engineering effort; Helicopter landing zones; Military bases; Temperate regions; Terrain analysis; [Ft. Bragg, N.C.; Ft. Stewart, Ga.]

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| 1. ORIGINATING ACTIVITY (Corporate author)<br>U. S. Army Engineer Waterways Experiment Station<br>Vicksburg, Miss. | 2a. REPORT SECURITY CLASSIFICATION<br>Unclassified<br>2b. GROUP |

3. REPORT TITLE

IDENTIFYING SOIL PARAMETERS WITH AN INFRARED SPECTROPHOTOMETER

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final report

5. AUTHOR(S) (Last name, first name, initial)

Shockley, W. G.
Knight, S. J.
Lipscomb, E. B.

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| 6. REPORT DATE<br>January 1963 | 7a. TOTAL NO. OF PAGES<br>30 | 7b. NO. OF REFS |

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| 8a. CONTRACT OR GRANT NO.<br>b. PROJECT NO. 1-T-0-21701-A-046, Trafficability and Mobility Research<br>c. Task -04, Mobility Terrain Analysis and Symbology<br>d. | 9a. ORIGINATOR'S REPORT NUMBER(S)<br>Miscellaneous Paper No. 4-547<br>9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)<br>AD 744 220 |

10. AVAILABILITY/LIMITATION NOTICES

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| 11. SUPPLEMENTARY NOTES Published in Proceed. of Second Symposium on Remote Sensing of Environment, University of Michigan, October 1962. | 12. SPONSORING MILITARY ACTIVITY<br>U. S. Army Materiel Command<br>Washington, D. C. 20315 |

13. ABSTRACT

This paper discusses the overall aims and objectives of the Waterways Experiment Station program in terrain interrogation using sensors operating in certain portions of the electromagnetic spectrum, describes the infrared equipment and tests conducted, and analyzes results obtained.

KEYWORDS: Infrared detectors; Infrared rays; Laboratory tests; Remote sensing; Soils; Trafficability

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| 1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Miss. | 2a. REPORT SECURITY CLASSIFICATION Unclassified<br>2b. GROUP |

3. REPORT TITLE

VISIT TO SWAMP FOX II OPERATION

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final report

5. AUTHOR(S) (Last name, first name, initial)

Rush, E. S.
Garrett, E. E.

| 6. REPORT DATE | 7a. TOTAL NO. OF PAGES | 7b. NO. OF REFS |
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| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY |
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| See TR 3-609 for Swamp Fox I operation. | U. S. Army Materiel Command Washington, D. C. 20315 |

13. ABSTRACT

Operation Swamp Fox II (U. S. Army Transportation Board Project TCB-62-176-EO) was the third of a series of environmental operations conducted by the Transportation Board in the Republic of Panama, and was designed to provide more complete scientific-engineering research of environment-vehicle relation by establishing a base camp and conducting tests under controlled conditions. Most of the basic trafficability data was made available to the U. S. Army Engineer Waterways Experiment Station observers by the mobility test team because WES participation was limited to the period 29 September-15 October 1962. The analysis was made by the authors. The other data and information reported were collected, at least in part, by the authors. This memorandum was prepared for record purposes.

KEYWORDS: Field tests; Military vehicles; Mobility; Trafficability; Tropical regions; [Panama; Swamp Fox]; Terrain analysis

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| 1. ORIGINATING ACTIVITY (Corporate author)<br>U. S. Army Engineer Waterways Experiment Station<br>Vicksburg, Mississippi | 2a. REPORT SECURITY CLASSIFICATION<br>Unclassified<br>2b. GROUP |
| 3. REPORT TITLE<br>TERRAIN EVALUATION FOR MOBILITY PURPOSES | |
| 4. DESCRIPTIVE NOTES (Type of report and inclusive dates) | |
| 5. AUTHOR(S) (First name, middle initial, last name)<br>Warren E. Grabau | |
| 6. REPORT DATE<br>July 1963 | 7a. TOTAL NO. OF PAGES<br>19<br>7b. NO. OF REFS |
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| 11. SUPPLEMENTARY NOTES<br>Paper prepared for publication in Journal of Terramechanics, Vol.1, No.2, 1964, pp.22-32. | 12. SPONSORING MILITARY ACTIVITY<br>Office, Chief of Engineers<br>Department of the Army<br>Washington, D. C. |

13. ABSTRACT

This paper describes the study of the effects of terrain on military activities; most of the effort so far has been concentrated on a study of the environment as it affects vehicular mobility. The families of the factors thus far dealt with are surface geometry, surface composition, hydrologic geometry, and vegetation. The surface geometry family is concerned only with the physical shape of the surface of the earth and is subdivided into the gross surface geometry (macrogeometry) and the minor surface irregularities (microgeometry). An arbitrary relief of 10 ft has been selected as the dividing criterion. The surface composition family is concerned with the physical characteristics of the materials of which the surface is composed. The shape, size, and distribution of water bodies of all kinds are characteristics described by the hydrologic geometry family. The vegetation factor family is concerned only with the geometry of the vegetation structure as a whole and not with the taxonomy of the individual plants. On the basis of tests, it was determined that (a) surface microgeometry exhibits the greatest effect on vehicular movement, and (b) critical tree spacing appears to be more closely related to vehicle length and not to turning radius.

KEYWORDS: Mobility; Terrain analysis; Terrain classification; Terrain factors

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| 1. ORIGINATING ACTIVITY (Corporate author)<br>U. S. Army Engineer Waterways Experiment Station<br>Vicksburg, Miss. | 2a. REPORT SECURITY CLASSIFICATION<br>Unclassified<br>2b. GROUP |

**3. REPORT TITLE**

VISIT TO UNIVERSITY OF ILLINOIS TO DISCUSS TROPICAL SOILS STUDY

**4. DESCRIPTIVE NOTES** *(Type of report and inclusive dates)*

Final report

**5. AUTHOR(S)** *(Last name, first name, initial)*

Carlson, C. A.

| 6. REPORT DATE | 7a. TOTAL NO. OF PAGES | 7b. NO. OF REFS |
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| 8a. CONTRACT OR GRANT NO. | 9a. ORIGINATOR'S REPORT NUMBER(S) |
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| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY |
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| | U. S. Army Materiel Command<br>Washington, D. C. 20315 |

**13. ABSTRACT**

Professor D. U. Deere summarized his experiences in the testing and use of tropical soils. Many soils contain minerals that dry irreversibly; hence, all laboratory testing of tropical soils must be started with field-moist material. Even with this precaution, prescribed optimum moisture-density values could not always be obtained in the field because of a continually wet environment. Chemical and mineralogical analyses were suggested to determine what constituents and soils were subject to irreversible drying.

KEYWORDS: Meetings; Soil tests (Laboratory); Trafficability; Tropical regions

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| 1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Miss. | 2a. REPORT SECURITY CLASSIFICATION Unclassified<br>2b. GROUP |
| 3. REPORT TITLE STUDY OF THE CHARACTERISTICS OF RICE FIELDS IN THE UNITED STATES | |
| 4. DESCRIPTIVE NOTES (Type of report and inclusive dates) Final report | |
| 5. AUTHOR(S) (Last name, first name, initial) Kennedy, J. G. | |
| 6. REPORT DATE October 1963 | 7a. TOTAL NO. OF PAGES 53 — 7b. NO. OF REFS 21 |
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| 10. AVAILABILITY/LIMITATION NOTICES Approved for public release; distribution unlimited. | |
| 11. SUPPLEMENTARY NOTES Service agent: U. S. Army Materiel Command Washington, D. C. 20315 | 12. SPONSORING MILITARY ACTIVITY Advanced Research Projects Agency Washington, D. C. 20315 |

13. ABSTRACT

This is a report of the first of many trips made to rice fields in Stuttgart and Kelso, Ark., and Crowley, La., in a study to determine seasonal characteristics of the rice fields pertinent to military operations. Soil, terrain geometry, vegetation, and hydrologic geometry data collected during the peak of the wet season are reported and discussed.

KEYWORDS: Mobility; Rice fields; Terrain factors; Trafficability data; [Arkansas; Louisiana]

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3. REPORT TITLE

MILITARY EVALUATION OF GEOGRAPHIC AREAS, REPORTS ON ACTIVITIES TO APRIL 1963

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

5. AUTHOR(S) (First name, middle initial, last name)

Anonymous

| 6. REPORT DATE | 7a. TOTAL NO. OF PAGES | 7b. NO. OF REFS |
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10. DISTRIBUTION STATEMENT

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| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY<br>U. S. Army Materiel Command<br>Washington, D. C. 20315 |

13. ABSTRACT

This report consists of 22 papers which were presented at a meeting of the Board of Consultants for the project "Military Evaluation of Geographic Areas" (MEGA), Project No. 1-T-0-25001-A-131, held at the U. S. Army Engineer Waterways Experiment Station on 17-18 April 1963. The presentations were intended to describe the major research activities of the MEGA project, to discuss the present status of the research, to define the most important problems faced in each activity, and to propose a research program in general terms for the future.

KEYWORDS: Meetings; State-of-the-art studies; Terrain analysis

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| 1. ORIGINATING ACTIVITY (Corporate author)<br>U. S. Army Engineer Waterways Experiment Station<br>Vicksburg, Miss. | 2a. REPORT SECURITY CLASSIFICATION<br>Unclassified<br>2b. GROUP |

3. REPORT TITLE

TERRAIN RECONNAISSANCE WITH ELECTROMAGNETIC SENSORS

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

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5. AUTHOR(S) (Last name, first name, initial)

Lipscomb, E. B.

| 6. REPORT DATE | 7a. TOTAL NO. OF PAGES | 7b. NO. OF REFS |
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| 8a. CONTRACT OR GRANT NO.<br>b. PROJECT NO. 1-T-0-21701-A-046, Trafficability and Mobility Research<br>c. Task -04, Mobility Terrain Analysis and Symbology<br>d. | 9a. ORIGINATOR'S REPORT NUMBER(S)<br>Miscellaneous Paper No. 4-630<br>9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) |

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| 11. SUPPLEMENTARY NOTES<br>Publisned in The Military Engineer, November-December 1963, Vol 55. | 12. SPONSORING MILITARY ACTIVITY<br>U. S. Army Materiel Command<br>Washington, D. C. 20315 |

13. ABSTRACT


The Terrain Analyzer Project of the Waterways Experiment Station is aimed at exploiting the electromagnetic spectrum as a means of identifying and quantifying those elements of the terrain that have an effect on military operations. This paper describes the project, which is in its first, or laboratory, phase. Infrared, radar, and gamma-ray studies are discussed.



KEYWORDS: Gamma rays; Infrared rays, Laboratory tests; Radar ; Remote sensing; Soils; Trafficability


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3. REPORT TITLE

VARIATION IN THE TRAFFICABILITY OF SANDS

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final report

5. AUTHOR(S) (Last name, first name, initial)

Knight, S. J.
Boyd, C. W.

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| 11. SUPPLEMENTARY NOTES<br>Published in The Military Engineer, Vol. 56, No. 372, July-August 1964. | 12. SPONSORING MILITARY ACTIVITY<br>U. S. Army Materiel Command<br>Washington, D. C. 20315 |

13. ABSTRACT


An essential feature of military planning is a knowledge of the trafficability of various soils, i.e. the ability of the soils to support the passage of various military vehicles. In this article, the variation that occurs in the strength or trafficability of sands is described. The sands discussed classify as SP or SW under the Unified Soil Classification System, and are in a "dry-to-moist" condition. Such sands are characteristic of inland deserts and of the portions of beaches of continental island shores not actually undergoing wetting by wave action. The sands discussed do not include those in very wet condition, since the behavior of these sands under vehicular traffic is quite different from that of dry-to-moist sands.



KEYWORDS: Coarse-grained soils; Sands; Soil strength; Trafficability


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U. S. Army Engineer Waterways Experiment Station
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2a. REPORT SECURITY CLASSIFICATION
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2b. GROUP

3. REPORT TITLE
A COMPARISON OF QUANTITATIVE VERSUS NONQUANTITATIVE TERRAIN DESCRIPTIVE SYSTEMS FOR MOBILITY ANALYSIS

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

5. AUTHOR(S) (First name, middle initial, last name)
Warren E. Grabau

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9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)
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10. DISTRIBUTION STATEMENT
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11. SUPPLEMENTARY NOTES Presented at a meeting of the Terrain Sub-Group of the Tripartite Working Group on Ground Mobility, Oxford, England, 24 June 1963

12. SPONSORING MILITARY ACTIVITY
U. S. Army Materiel Command
Washington, D. C.

13. ABSTRACT
The results of vehicle tests have shown that quantitative descriptive and classification systems constitute the most practical basis for terrain evaluation for mobility purposes and that once such systems are available, test sequences can be conducted in known environments which can be extended with nearly complete confidence to other areas of the world which exhibit the same numerical parameters upon analysis. Existing traditional literature on landforms can be associated with quantitative descriptive systems and stored on computer systems for later use in mobility prediction systems. Three basic programs are being conducted at the Waterways Experiment Station in the field of mobility research: (a) the development of detailed quantitative systems for describing and classifying environments, (b) the testing of the responses of vehicles to known environments, classified both quantitatively and traditionally, and (c) the correlation of traditional classifications with quantitative classifications.

KEYWORDS: Mobility; Terrain analysis; Terrain classification; Terrain factors

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3. REPORT TITLE

REPORT OF SECOND MEETING OF ARPA ADVISORY COMMITTEE ON MOBILITY ENVIRONMENTAL RESEARCH STUDY (24-26 February 1964, Vicksburg, Mississippi)

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Progress report to February 1964

5. AUTHOR(S) (First name, middle initial, last name)

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| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY |
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| | Advanced Research Projects Agency |

13. ABSTRACT


This report consists of 18 papers presented at the Advisory Committee meeting, summaries of important discussions and questions relative to the various papers, the Committee's conclusions and recommendations, and a report of an Ad Hoc Working Group recommended by the Committee to examine the applicability of an airborne profilometer to obtain terrain profiles. The papers included reports on WES studies related to Project MERS, review of project history, conclusions and recommendations of the first Advisory Committee meeting held at Bethesda, Maryland, on 7-9 November 1962, accomplishments on Project MERS tasks since the first committee meeting, Marsh Screw Amphibian tests conducted by WES, Project MERS plans for the next 12 months, and funding status and requirements for fiscal year 1965.



KEYWORDS: Meetings; Mobility; State-of-the-art studies; Trafficability


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| 1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Mississippi | 2a. REPORT SECURITY CLASSIFICATION Unclassified |
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3. REPORT TITLE

RETENTION OF DETAIL IN MAP GENERALIZATION

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

5. AUTHOR(S) (First name, middle initial, last name)

Warren E. Grabau and Eugene E. Addor

| 6. REPORT DATE | 7a. TOTAL NO. OF PAGES | 7b. NO. OF REFS |
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| d. | AD 745 149 |

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| 11. SUPPLEMENTARY NOTES Paper prepared for presentation at 1964 Regional Convention of the American Congress on Surveying & Mapping, Kansas City, Mo., 24-26 Sep 1964 | 12. SPONSORING MILITARY ACTIVITY U. S. Army Materiel Command Washington, D. C. |

13. ABSTRACT

The distribution of things in any approximately homogeneous population can be adequately described by a sample which is coincident with a minimal area called the "structural cell." The smallest area which can be depicted on any map is a function of the map scale and is called a "mapping cell." Areas of lesser extent than the mapping cell cannot be shown and are therefore merged into the map unit of greater occupance, resulting in a map unit characterized in the legend as a single population, but in fact representing areas composed of two or more populations. Such a map unit has a "reliability" of substantially less than 100 percent. Retention of detail with scale reduction depends upon recognition of the scalar relationships between the mapping cell and the structural cells of the populations being mapped. The boundaries between the units are generalized according to a set of prescribed rules, and a legend is designed consisting of diagrammatic representations of "unit areas" in which the relative proportions, as well as the schematic positional relations of all populations comprising the generalized map unit are identified.

KEYWORDS: Terrain analysis; Terrain mapping

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| 1. ORIGINATING ACTIVITY (Corporate author)<br>U. S. Army Engineer Waterways Experiment Station<br>Vicksburg, Mississippi | 2a. REPORT SECURITY CLASSIFICATION<br>Unclassified<br>2b. GROUP |

3. REPORT TITLE
MOBILITY ENVIRONMENTAL RESEARCH STUDY: SELECTION AND DESCRIPTION OF TEST AREAS U. S. MILITARY RESERVATIONS

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
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5. AUTHOR(S) (Last name, first name, initial)
Woods, Harry K.
Shamburger, John H.

| 6. REPORT DATE | 7a. TOTAL NO. OF PAGES | 7b. NO. OF REFS |
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| c. ARPA Order No. 400 | 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)<br>AD 745 151 |
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| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY |
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| Service Agent:<br>Army Materiel Command<br>Washington, D. C. | Office, Secretary of Defense<br>Advanced Research Projects Agency<br>Washington, D. C. |

13. ABSTRACT

One of the tasks in connection with obstacles studies to develop the capability to predict in quantitative terms the effects of terrain obstacles on cross-country performance of ground vehicles was entitled "Proof Tests of Ground Mobility in the U. S." This report is concerned with the first phase of the proof tests, selection and preliminary description of test areas selected for examination on 15 military reservations. The terrain factors considered as having an obstacle-producing effect on vehicle performance were vegetation, surface microgeometry, and surface macrogeometry (principally slope). Areas within the 15 reservations meeting established criteria were tentatively located through an airphoto interpretation study. The terrain characteristics were measured at the selected sites during ground reconnaissances. These data were analyzed and the reservations were categorized according to the availability of sites for conducting single- and multiple-factor tests. Camp Lejeune, N. C., Camp A. P. Hill, Va., and Eglin AFB, Fla., offer more areas suitable for conducting single-factor tests than the other reservations. A variety of combinations of slopes and stem spacing desirable for conducting multiple-factor tests is present at Camp A. P. Hill, Va., Camp Pickett, Va., and Quantico Marine Schools, Va.

KEYWORDS: Military bases; Temperate regions; Terrain analysis; Terrain factors; Terrain mapping

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3. REPORT TITLE

STATISTICAL EVALUATION OF CONE-PENETRATION-TEST DATA

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

5. AUTHOR(S) (First name, middle initial, last name)

J. K. Poplin

| 6. REPORT DATE | 7a. TOTAL NO. OF PAGES | 7b. NO. OF REFS |
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| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY |
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| | Defense Atomic Support Agency<br>and Office, Chief of Engineers |

13. ABSTRACT

An investigation was conducted using a typical laboratory specimen and 121 penetrations were made with a 1/2-in.-diam 30-deg cone penetrometer. The penetrations were made at 6-in. spacings in various patterns to study the effect of penetration sequence, interaction, and boundaries. In addition, 25 density samples were taken from the specimen and a single plate-bearing test using a 6-in.-square plate was conducted. The cone-penetration-resistance data and density data were subjected to standard statistical analysis. Differences in mean values from different zones in the specimen were compared to determine if real differences existed and were not the result of random scatter in data. Density data indicated that the specimen was uniform within the capabilities of determination but that variations not accountable as random scatter in cone-penetration resistance existed between various points in the specimen. Cone-penetration resistance was found to be adequate for evaluating uniformity provided sufficient observations were made. Generally, about eight penetrations were required to yield a mean value which could be expected to be within 6 percent of the true mean value.

KEYWORDS: Cone penetration tests; Laboratory tests; Penetration resistance (Soils); Plate bearing tests; Sands; Soil density; Soil penetration tests; Soil property variations; Soil strength

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| 1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Miss. | 2a. REPORT SECURITY CLASSIFICATION Unclassified<br>2b GROUP |
| 3. REPORT TITLE REPORT OF CONFERENCE OF THE BOARD OF CONSULTANTS ON REMOTE TERRAIN ANALYSIS BY ELECTROMAGNETIC MEANS; WATERWAYS EXPERIMENT STATION, 18-19 NOVEMBER 1965 | |
| 4. DESCRIPTIVE NOTES (Type of report and inclusive dates) Final report | |
| 5. AUTHOR(S) (Last name, first name, initial) Not applicable | |

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| 10. AVAILABILITY/LIMITATION NOTICES Approved for public release; distribution unlimited. | |
| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY U. S. Army Materiel Command Washington, D. C. 20315 |

13. ABSTRACT

A conference of the Board of Consultants on Remote Terrain Analysis by Electromagnetic Means was held at the U. S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi, on 18-19 November 1965. Only summaries of the technical papers presented are given herein; complete texts of these presentations of test programs and results to date will be published as WES technical reports under the general title Terrain Analysis by Electromagnetic Means. Exhibit 1 is the program for the meeting, and Exhibit 2 is a list of attendants. Exhibit 3 describes proposed future plans. Exhibit 4 presents the report prepared by the Board of Consultants at the conclusion of the conference.

KEYWORDS: Electromagnetic radiation; Meetings; Remote sensing; Soils; State-of-the-art studies; Terrain analysis; Trafficability

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U. S. Army Engineer Waterways Experiment Station
Vicksburg, Miss.

2a. REPORT SECURITY CLASSIFICATION
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3. REPORT TITLE
EFFECTS OF SOIL LAYERING ON THE USE OF VHF RADIO WAVES FOR REMOTE TERRAIN ANALYSIS

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
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5. AUTHOR(S) (Last name, first name, initial)
Nikodem, H. J.

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11. SUPPLEMENTARY NOTES Published in Proceedings of the Fourth Symposium on Remote Sensing of Environment at Univ. of Mich., Ann Arbor, Mich., 12-14 Apr 66

12. SPONSORING MILITARY ACTIVITY
U. S. Army Materiel Command
Washington, D. C. 20315

13. ABSTRACT

Laboratory studies have been conducted at the Waterways Experiment Station to determine the effects of soil layering on the quantity of reflected energy measured from terrain. The results of this study indicate that reflections from subsurface interfaces can have a drastic influence on the quantity of energy measured and that standard monochromatic pulsed-radar systems are not suitable for measuring subsurface soil conditions. Systems employing swept-frequency techniques are needed to allow direct measurement of electrical properties of the soils. These properties then can be correlated with the thickness of the upper layer and the moisture content of the soil.

Besides soil layers, such factors as soil conductivity and vegetation determine the usable wavelength region. The effects of each of these are discussed and examples of several soil-layering profiles that might be encountered in natural terrain are given. The limits to which the layering profiles of the soils influence the return energy are illustrated. These limits are determined by the thicknesses of the layers and the electrical properties of the soil comprising each layer.

KEYWORDS: Laboratory tests; Radio waves; Remote sensing; Soil stratification; Soils

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3. REPORT TITLE

LABORATORY INVESTIGATIONS OF THE GAMMA-RAY SPECTRAL REGION FOR REMOTE DETERMINATION OF SOIL TRAFFICABILITY CONDITIONS

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

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5. AUTHOR(S) (Last name, first name, initial)

Williamson, Albert N., Jr.

| 6. REPORT DATE | 7a. TOTAL NO. OF PAGES | 7b. NO. OF REFS |
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| b. PROJECT NO. 1-V-0-21701-A-046, Trafficability and Mobility Research | Miscellaneous Paper No. 4-823 |
| c. Task -04, Mobility Terrain Analysis and Symbology<br>d. | 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)<br>AD 747 097 |

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| 11. SUPPLEMENTARY NOTES Published in Proceedings of the Fourth Symposium on Remote Sensing of Environment held at the Univ of Mich., Ann Arbor, Mich., Apr 1966. | 12. SPONSORING MILITARY ACTIVITY<br>U. S. Army Materiel Command<br>Washington, D. C. 20315 |

13. ABSTRACT


Gamma radiation from soil samples was measured, and the results were analyzed to evaluate the use of gamma rays in remotely determining soil parameters useful in estimating trafficability. Gamma-ray spectra were obtained from representative samples of sand, silt, and clay placed in a low-background inclosure. Photopeak counting rates and photopeak ratios of thorium, uranium, potassium were considered in the analysis. Results indicated that photopeak counts of the radioisotopes of primary interest were proportional to moisture content of the soil samples, but ratios of the photopeaks were nearly independent of moisture content, although different for each soil tested.

Gamma-ray measurements were also made on soil samples obtained from all 50 states in an attempt to correlate the ratios of their photopeaks of thorium, uranium, and potassium with soil type and other morphological, genetic, and physical-chemical characteristics of the soils.



KEYWORDS: Gamma rays; Laboratory tests; Remote sensing; Soils; Trafficability


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| 3. REPORT TITLE<br>COMPARISON OF GROUND MOBILITY CHARACTERISTICS OF LAND-MARINE INTERFACES OF FLORIDA AND THAILAND | |
| 4. DESCRIPTIVE NOTES (Type of report and inclusive dates)<br>Final report | |
| 5. AUTHOR(S) (Last name, first name, initial)<br>Garrett, E. E. | |
| 6. REPORT DATE<br>August 1966 | 7a. TOTAL NO. OF PAGES: 79<br>7b. NO. OF REFS: 7 |
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| 10. AVAILABILITY/LIMITATION NOTICES<br>Approved for public release; distribution unlimited. | |
| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY<br>Advanced Research Projects Agency and<br>U. S. Army Materiel Command<br>Washington, D. C. 20315 |

13. ABSTRACT

A semiquantitative system for describing the pertinent characteristics of land-marine interfaces with regard to ground mobility is developed and presented herein. The description involves the subjective identification of characteristic zones of the interface, and the measurement or designation of significant properties of those zones. The range of values or designation exhibited by each property is divided into suitable classes, and each class is assigned a code number. A total of 27 coastal sites in northwest and west central Florida and the Florida Keys and 14 coastal sites in Thailand are evaluated according to the newly developed system. A comparison of the Florida and Thailand coastal sites based on relative frequencies of occurrence of the range of values of each property is presented, and areas that may be expected to show some degree of similarity are identified. General conclusions are: (a) land-marine interfaces on the Gulf of Siam have characteristics that are closely approximated on the northwest and west central coasts of Florida, (b) the land-marine interfaces on these shores exhibit a close analogy when compared with regard to structural zones, and (c) land-marine interfaces of the two areas not within a gulf environment (i.e. those not protected from oceanic wave attack) exhibit divergent characteristics.

KEYWORDS: Beach trafficability; Coasts; Land-water interface; Mobility; Terrain analogs; Terrain factors; Tropical regions; [Florida; Thailand]

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| 3. REPORT TITLE<br>VARIATION IN TRAFFICABILITY OF FOUR LOESS SOILS | | | |
| 4. DESCRIPTIVE NOTES (Type of report and inclusive dates)<br>Final Report | | | |
| 5. AUTHOR(S) (Last name, first name, initial)<br>Bassett, John R.<br>McDaniel, Alvin R.<br>Knight, Sterling J. | | | |
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| 8a. CONTRACT OR GRANT NO.<br>b. PROJECT NO. 1-V-0-21701-A-046, Trafficability and Mobility Research<br>c. Task -02, Surface Mobility<br>d. | 9a. ORIGINATOR'S REPORT NUMBER(S)<br>Miscellaneous Paper No. 4-838<br>9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)<br>AD 800 144 | | |
| 10. AVAILABILITY/LIMITATION NOTICES<br>Approved for public release; distribution unlimited. | | | |
| 11. SUPPLEMENTARY NOTES<br>Published in SSSA Proceedings, Vol 31, No. 1, Jan-Feb 1967, titled "Trafficability of Four Loess Soils." | 12. SPONSORING MILITARY ACTIVITY<br>U. S. Army Materiel Command<br>Washington, D. C. 20315 | | |

13. ABSTRACT


Grain-size distribution, Atterberg limits, organic matter content, dry unit weight, field moisture content, and strength of the 6- to 12-in. soil layer were measured once during the wet season at 65 test sites located in northeast Louisiana and southeast Arkansas. Soils were modal silt loams of four related series: Loring, Grenada, Calloway, and Henry. Series descriptions and typical soil profiles of the soil series are given in Appendix A. Regression analysis was used to relate cone index, remolding index, and rating cone index, respectively, to moisture content for all series, individually and grouped. Differences between individual series regressions were not significant (0.05 level). The group equation for rating cone index was significant (0.01 level) and explained 66 percent of the variation in rating cone index associated with changes in moisture content. To illustrate use of the results, the group equation for rating cone index was used to estimate the trafficability of a forested area for a TD-9 tractor for each day of a 16-month period. The estimates agreed closely with observed field conditions, suggesting that the four series can be combined for trafficability classification.



KEYWORDS: Field tests; Loess; Soil property relations; Soil property variations; Trafficability; [Arkansas; Louisiana]


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| 3. REPORT TITLE<br>TERRAIN EVALUATION OF A PORTION OF THE FORT GREELY AUTOMOTIVE TEST COURSE | |
| 4. DESCRIPTIVE NOTES (Type of report and inclusive dates)<br>Final report | |
| 5. AUTHOR(S) (Last name, first name, initial)<br>Shamburger, John H.<br>Kolb, Charles R.<br>Woods, Harry K. | |
| 6. REPORT DATE<br>December 1966 | 7a. TOTAL NO. OF PAGES<br>67<br>7b. NO. OF REFS<br>7 |
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| 10. AVAILABILITY/LIMITATION NOTICES<br>Approved for public release; distribution unlimited. | |
| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY<br>U. S. Army Arctic Test Center<br>Fort Greely, Alaska |

13. ABSTRACT

A method for classifying and mapping terrain features pertinent to off-road mobility in selected temperate, tropical, and desert areas was applied to subarctic terrain in this study. The area involved borders the Automotive Test Course of the U. S. Army Arctic Test Center at Fort Greely, Alaska, and is roughly 2000 ft wide and 15 miles long. Conditions mapped were those prevalent during the late summer. The classification and mapping method proved satisfactory with only minor modifications. Terrain factors unique to cold regions which require additional research before they can be properly classified and mapped for mobility test purposes include depth of thaw, snow depth, snow type, ice thickness, and stream turbidity.

KEYWORDS: Military bases; Offroad mobility; Subarctic regions; Terrain analysis; Terrain classification; Terrain mapping; [Fort Greely, Alaska]

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3. REPORT TITLE

REPORT OF CONFERENCE ON SOIL TRAFFICABILITY PREDICTION, U. S. ARMY ENGINEER WATERWAYS EXPERIMENT STATION, 29-30 NOVEMBER 1966

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

5. AUTHOR(S) (First name, middle initial, last name)

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| 6. REPORT DATE | 7a. TOTAL NO. OF PAGES | 7b. NO. OF REFS |
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10. DISTRIBUTION STATEMENT

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| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY |
|---|---|
| | U. S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi |

13. ABSTRACT

This report summarizes the discussions of a meeting held at the U. S. Army Engineer Waterways Experiment Station on 29-30 November 1966 to review the progress of studies related to soil trafficability prediction conducted since the last consultants meeting in 1958 and to afford the consultants an opportunity to comment on problem areas and make recommendations for future research. Summaries were presented on studies as follows: methods of soil moisture prediction for trafficability purposes (C. A. Carlson); effects and deficiencies of factors used in WES soil moisture prediction system (A. R. McDanial); a tentative soil strength prediction system; influence of water tables on soil moisture and soil strength (J. G. Collins); influence of soil variability on soil moisture and soil strength predictions (H. D. Molthan); comparison of soil moisture prediction factors for temperate and tropical climates (M. H. Smith); predicting and portraying soil moisture on an areal basis in Costa Rica (A. R. McDanial); and soil trafficability classification scheme (M. P. Meyer).

KEYWORDS: Meetings; Soil moisture prediction; Soil strength prediction; State-of-the-art studies; Trafficability; Trafficability prediction

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| 1. ORIGINATING ACTIVITY (Corporate author)<br>U. S. Army Engineer Waterways Experiment Station<br>Vicksburg, Miss. | 2a. REPORT SECURITY CLASSIFICATION<br>Unclassified<br>2b. GROUP |
| 3. REPORT TITLE<br>SPECIAL SITE DESCRIPTION, PANAMA CANAL ZONE | |
| 4. DESCRIPTIVE NOTES (Type of report and inclusive dates)<br>Final report | |
| 5. AUTHOR(S) (Last name, first name, initial)<br>Grabau, Warren E.<br>Benn, Bob O. | |

| 6. REPORT DATE | 7a. TOTAL NO OF PAGES | 7b. NO OF REFS |
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| 10. AVAILABILITY/LIMITATION NOTICES<br>Approved for public release; distribution unlimited. | |
| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY<br>Joint Chiefs of Staff<br>Service Agency<br>Program Manager for Selected Ammunition |

13. ABSTRACT

Evaluation tests of munitions selected as suitable for airdrop were conducted by the U. S. Air Force in the Panama Canal Zone in October 1966. In association with these tests an important task was to document those characteristics of the environment which were assumed to affect that special activity. Therefore, the U. S. Army Engineer Waterways Experiment Station (WES) was engaged by the Air Force to provide the environmental characterization for the Air Force test sites. The purposes of this report are to provide (a) a general description of the test areas, and (b) a record of environmental conditions in the test areas that, along with the activity record, would furnish an analyst with sufficient objective data to permit a search for the cause-and-effect relations pertinent to this activity. The general description of the test areas is presented in the form of location maps, air and ground photographs, and center-line profiles. The record of environmental conditions provided concerns only those parameters deemed pertinent to the activity being studied. These parameters are visual appearance, topographic setting, surface composition, vegetation structure, and vegetation taxonomy. Stem spacing by heights and stem diameters were ascertained by computer. A procedure for sampling vegetation physiognomy is included as Appendix A, and the data reduction program for the results of this sampling procedure is included as Appendix B.

KEYWORDS: Munition effectiveness; Terrain analysis; Terrain factors; Tropical regions; Vegetation factors; [Panama Canal Zone]

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| 1. ORIGINATING ACTIVITY (Corporate author)<br>U. S. Army Engineer Waterways Experiment Station<br>Vicksburg, Mississippi | 2a. REPORT SECURITY CLASSIFICATION<br>UNCLASSIFIED<br>2b. GROUP |

3. REPORT TITLE

ENVIRONMENTAL CHARACTERISTICS OF TUNNELS IN SOUTH VIETNAM

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

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5. AUTHOR(S) (Last name, first name, initial)

Eugene E. Addor

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| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY |
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| | Advanced Research Projects Agency, Directorate of Remote Area Conflict, and U. S. Army Materiel Command |

13. ABSTRACT

The purpose of the present study was to gather quantitative measurements of various environmental factors in and around tunnel complexes, for guidance in establishing the suitability or the sensitivity requirements of various experimental or hypothetical sensor systems. The report consists mostly of a straightforward compilation of the collected data, with descriptions of the instruments and procedures employed, and an analysis of their failures. Except for directing attention to certain points which may be of interest to those engaged in sensor development, there is but minimal attempt here at interpretation of the data in terms of sensor requirements. The data were collected during March and early April 1967, which is about the latter part of the dry season for the area studied. The factors measured and for which data are included in this report are: (a) tunnel geometry, (b) surface composition, (c) microclimate, (d) vegetation, and (e) visual appearance and reflectivity.

KEYWORDS: Environmental analysis; Environmental factors; Sensors; Tropical regions; Tunnel detection; [South Vietnam]

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| 1. ORIGINATING ACTIVITY (Corporate author)<br>U. S. Army Engineer Waterways Experiment Station<br>Vicksburg, Miss. | 2a. REPORT SECURITY CLASSIFICATION<br>Unclassified<br>2b. GROUP |

3. REPORT TITLE

A SUGGESTED PROCEDURE FOR THE SELECTION AND DESCRIPTION OF REFERENCE TEST AREAS

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
Final report

5. AUTHOR(S) (First name, middle initial, last name)

Warren E. Grabau

| 6. REPORT DATE | 7a. TOTAL NO. OF PAGES | 7b. NO. OF REFS |
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| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY |
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| | U. S. Army Materiel Command |


13. ABSTRACT A procedure is presented for the selection and description of reference test areas (RTA's) in which the Quadripartite nations can test and evaluate their military vehicles. The procedure consists of four phases:

- a. Selection of areas of national interest by each of the Quadripartite nations.
- b. Identification and description of the facets comprising the areas of national interest.
- c. Selection of RTA's within each member nation in a location which exhibits the maximum number of facet types as found in the areas of national interest.
- d. Description of all RTA's in terms of landscape pattern, facet and subfacet composition, factor value ranges characterizing each facet and subfacet, and factor values mapped independently.

The factor value descriptions must be in terms of ranges of values for those factors which significantly affect vehicle performance. The factors are hypothesized to be:

- a. Soil factors: soil mass strength, soil surface strength.
- b. Vertical obstacles: macroslope, step height, width, length, spacing, approach angle, soil mass strength.
- c. Lateral obstacles: spacing, stem spread, branching height, clustering index.
- d. Longitudinal obstacles: spacing, stem diameter, bending strength, clustering, soil mass strength.
- e. Water-land interface: depth, approach angle, current velocity.



KEYWORDS: Mobility; Reference test areas; Site selection; Terrain analysis; Terrain factors


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3. REPORT TITLE

EXPEDIENT SURFACE-SOIL SAMPLING

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final report

5. AUTHOR(S) (First name, middle initial, last name)

Sterling J. Knight
Claude A. Blackmon

| 6. REPORT DATE | 7a. TOTAL NO. OF PAGES | 7b. NO. OF REFS |
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| SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY<br>Office, Chief of Engineers<br>Department of the Army<br>Washington, D. C. 20315 |

13. ABSTRACT

A study was made to determine practical, expedient methods of securing and containing surface-soil samples when soil sampling equipment is not available. Detailed examination of 24 cans, digging tests with three cans, and soil moisture-retention tests of eight types of covers indicated that any all-metal can makes a good tool for digging and containing surface-soil samples. A 12-oz beer can is judged to be a good choice for expedient surface-soil sampling because of its ubiquity, size, shape, sturdiness, and resistance to corrosion. A plastic cover that fits a round can snugly and two types of cloth-backed adhesive tape are considered to be effective covers for retaining the moisture in a soil sample in a can. Detailed procedures for surface-soil sampling are given.

KEYWORDS: Soil sampling

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| 1. ORIGINATING ACTIVITY (Corporate author)<br>U. S. Army Waterways Experiment Station<br>Vicksburg, Miss. 39180 | 2a. REPORT SECURITY CLASSIFICATION<br>Unclassified<br>2b. GROUP |

3. REPORT TITLE

PENETRATION TESTS FOR SOIL MEASUREMENTS

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
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5. AUTHOR(S) (First name, middle initial, last name)

Freitag, D. R.

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| 8a. CONTRACT OR GRANT NO.<br>b. PROJECT NO. 1-V-0-21701-A-046, Trafficability and Mobility Research<br>c.<br>d. | 9a. ORIGINATOR'S REPORT NUMBER(S)<br>Miscellaneous Paper No. 4-960<br>9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)<br>AD A032 708 |

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| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY |
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| Presented at the 1967 Meeting of the American Society of Agricultural Engineers Detroit, Mich., 12-15 Dec 67 (Paper 67-652) | U. S. Army Materiel Command<br>Washington, D C. 20315 |

13. ABSTRACT

Penetrometers are well suited for measuring soil properties, but there are some factors that limit their applicability. Test data accumulated by the U. S. Army Engineer Waterways Experiment Station are used to identify these factors and to indicate their influence.

KEYWORDS: Penetrometers; Soil penetration tests; Soil property measurements

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3. REPORT TITLE

SUMMARY OF COMPARISON OF ENGINEERING PROPERTIES OF SELECTED TEMPERATE AND TROPICAL SURFACE SOILS

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Summary report

5. AUTHOR(S) (First name, middle initial, last name)

M. P. Meyer

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| Presented at Second International Conference on Mechanics of Soil-Vehicle Systems 8-66; & Geological Society of America 11-67 | Advanced Research Projects Agency and U. S. Army Materiel Command, Washington, D. C. |

13. ABSTRACT

This paper summarizes a report, "Comparison of Engineering Properties of Selected Temperate and Tropical Surface Soils," published in June 1966. Field and laboratory tests were conducted on 11 fine-grained soils from the temperate climate of the United States and 17 fine-grained soils from the tropical climates of Puerto Rico, Panama Canal Zone, Hawaii, and Thailand to determine trafficability of the soils and other engineering properties. Soils were collected from the 6- to 12-in. layer for a wide range of parent materials. Temperate and tropical soils of each parent material were selected on the basis of their similarity in the Unified Soil Classification System and topographic position. A comparison of physical, mineralogical, and chemical properties, and results of standard and special engineering tests indicate, with few exceptions, no significant differences between temperate and tropical soils from a similar parent material. It is concluded that temperate and tropical soils of similar parent materials and Atterberg limits generally have other engineering properties that are similar and behave similarly when subjected to standard and special engineering laboratory tests. Differences in behavior between soils from each of the climates can be associated with differences in Atterberg limits.

KEYWORDS: Laboratory tests; Parent materials (Soils); Soil property relations; Soil property variations; Temperate regions; Trafficability; Tropical regions, [Hawaii, Panama C Z, Puerto Rico, Thailand]

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3. REPORT TITLE
A QUANTITATIVE DESCRIPTION OF VEGETATION ON TWO SITES IN THE RAIN FOREST OF PUERTO RICO

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
Final report

5. AUTHOR(S) (First name, middle initial, last name)
William N. Rushing

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| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY |
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| | U. S. Army Materiel Command<br>Washington, D. C. |

13. ABSTRACT

Quantitative structural data on two forest sites, each 60 m in diameter, were collected at El Verde, Puerto Rico. From the data, detailed maps were drawn of the tree stems, boulders, stumps, and slash. Other vegetation data, both structural and taxonomic, were collected and are available for the sampled areas. Structural diagrams symbolizing the forests, and a discussion of the WES technique for drawing them, are included.

KEYWORDS: Rain forests; Tropical regions; Vegetation mapping; Vegetation structure; [Puerto Rico]

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| 1. ORIGINATING ACTIVITY (Corporate author)<br>U. S. Army Engineer Waterways Experiment Station<br>Vicksburg, Mississippi | 2a. REPORT SECURITY CLASSIFICATION<br>Unclassified<br>2b. GROUP |

3. REPORT TITLE

GAMMA-RAY MEASUREMENTS TO EVALUATE SOIL PROPERTIES

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

5. AUTHOR(S) (First name, middle initial, last name)

Albert N. Williamson

| 6. REPORT DATE | 7a. TOTAL NO. OF PAGES | 7b. NO. OF REFS |
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| 11. SUPPLEMENTARY NOTES Paper presented at Fifth Symposium on Remote Sensing of Environment, University of Michigan, 16-18 April 1968; Published in Proceedings. | 12. SPONSORING MILITARY ACTIVITY<br>U. S. Army Materiel Command<br>Washington, D. C. |

13. ABSTRACT

Gamma radiation from soil samples obtained from nearly all of the states and Puerto Rico was measured in the laboratory and the results were analyzed to evaluate the use of gamma-ray measurements to convey certain information about the soil. The data were arranged according to land usage, i.e. cultivated or uncultivated, and into classifications according to the following systems: geological material type, geological material age, U. S. Department of Agriculture (USDA) Great Soil Group, and USDA Soil Order based on the Seventh Approximation. By plotting the gamma-ray photopeak count ratios of $Th^{232}/K^{40}$ versus $U^{238}/K^{40}$ and the normalized photopeak counts for $U^{238}$ and $Th^{232}$ versus sand content, it was shown that the criteria for separating the soils were either too broad or not significant to the gamma-ray emissive characteristics of soil. However, the data showed that the $Th^{232}$ and $U^{238}$ photopeak counts depended upon the particle size distribution in the soil and indicated that gamma-ray measurements can provide a qualitative indication of sand content.

KEYWORDS: Gamma rays; Laboratory tests; Remote sensing; Soils

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| 1. ORIGINATING ACTIVITY *(Corporate author)*<br>U. S. Army Engineer Waterways Experiment Station<br>Vicksburg, Miss. | 2a. REPORT SECURITY CLASSIFICATION<br>Unclassified<br>2b. GROUP |

3. REPORT TITLE

A COMPUTER METHOD FOR DETERMINING UPPER CANOPY CLOSURE AT EL VERDE, PUERTO RICO

4. DESCRIPTIVE NOTES *(Type of report and inclusive dates)*

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5. AUTHOR(S) *(First name, middle initial, last name)*

A. Paul Desmarais

| 6. REPORT DATE | 7a. TOTAL NO. OF PAGES | 7b. NO. OF REFS |
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10. DISTRIBUTION STATEMENT

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| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY |
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| Published in The Rain Forest, AEC, 1970. | U. S. Army Materiel Command<br>Washington, D. C. |

13. ABSTRACT


Coverage of tree crowns (canopy closure) was studied along with other basic structural attributes of El Verde, Puerto Rico, test sites where canopy closure approaches a maximum (100 percent) in the dense rain forest. There are several methods of determining closure values. Any of these can be used in determining percent coverage by species or by structural type, or on any other basis. The fact that tree crowns overlap, sometimes quite extensively, makes it difficult to obtain coverage values by mathematical analysis because computations involving overlapping circles are mathematically complicated. To resolve the difficulty, a computer method was devised that converts the circular crown areas into squares of approximate equivalent area and calculates crown coverage and canopy closure on this basis. The method is described, and the results are compared with the more tedious manual methods. Three groups of plants were used as bases for closure determinations and comparisons. They were (a) all plants at the El Verde sites above 5 m in height; (b) all plants of the two most predominant species, Dacryodes excelsa Vahl and Sloanea berteriana Choisy, 5 to 13 m in height; and (c) all plants of the same species 13 m or more in height. The mathematical approach used to write the computer program is included as Appendix A.



KEYWORDS: Computer analysis; Crown characteristics (Vegetation); Rain forests; Tropical regions; Vegetation; [Puerto Rico]


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| 1. ORIGINATING ACTIVITY (Corporate author)<br>U. S. Army Engineer Waterways Experiment Station<br>Vicksburg, Mississippi | 2a. REPORT SECURITY CLASSIFICATION<br>Unclassified<br>2b. GROUP |

3. REPORT TITLE

EFFECTS OF CESIUM$^{137}$ IRRADIATION ON VEGETATION STRUCTURE AND OPTICAL DENSITY AT EL VERDE, PUERTO RICO

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

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5. AUTHOR(S) (First name, middle initial, last name)

A. Paul Desmarais
Billy T. Helmuth

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| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY |
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| Published in The Rain Forest, AEC, 1970. | U. S. Army Materiel Command<br>Washington, D. C. |

13. ABSTRACT

The vegetation physiognomies of both the radiation and control sites in the El Verde rain forest were described in 1964. A second description of the radiation site was made approximately sixteen months later. This was seven months after the radiation site had been exposed intermittently to 10,000 curies of radiation from a cesium$^{137}$ source for about three months. Optical density data were collected on both sites between May 1965 and July 1966. Significant changes were detected in both vegetation physiognomy and optical density to a distance of about 12 m from the center of the radiation site. During the course of the experiment it became evident that the measurement of optical density with silicon solar cells (spectral response 3600 to 11,400 A) was yielding anomalous data. Accordingly, a new and more convenient system was devised using selenium solar cells (spectral response 4000 to 7000 A), since these instruments have a spectral response more closely analogous to that of the human eye. Evaluation of the two instruments revealed that mean transmittance measured with the silicon cells was approximately twice that measured with selenium cells. This is interpreted to mean that infrared frequencies penetrate deeper into vegetation than do visible frequencies.

KEYWORDS: Irradiation; Optical density; Rain forests; Vegetation; Vegetation structure; [Cesium$^{137}$; Puerto Rico]

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| 1. ORIGINATING ACTIVITY (Corporate author)<br>U. S. Army Engineer Waterways Experiment Station<br>Vicksburg, Mississippi | 2a. REPORT SECURITY CLASSIFICATION<br>Unclassified<br>2b. GROUP |
| 3. REPORT TITLE<br>EFFECTS OF CONE VELOCITY AND SIZE ON SOIL PENETRATION RESISTANCE | |
| 4. DESCRIPTIVE NOTES (Type of report and inclusive dates)<br>Final report | |
| 5. AUTHOR(S) (First name, middle initial, last name)<br>Gerald W. Turnage<br>Dean R. Freitag | |

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| December 1969 | 27 | 3 |

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| 10. DISTRIBUTION STATEMENT<br>Approved for public release; distribution unlimited. | |
| 11. SUPPLEMENTARY NOTES<br>Presented ASAE Meeting, Dec 1969, Paper No. 69-670. | 12. SPONSORING MILITARY ACTIVITY<br>U. S. Army Materiel Command<br>Washington, D. C. |

13. ABSTRACT

Data show the cone penetration resistance of fine-grained soils is proportional to velocity and inversely proportional to cone diameter. An exponential equation based on the velocity-diameter ratio is developed to describe the interrelation. The exponent changes only slightly with soil type.

KEYWORDS: Cone penetrometers; Fine-grained soils; Penetration resistance (Soils)
Soil penetration tests

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| 1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi | 2a. REPORT SECURITY CLASSIFICATION Unclassified<br>2b. GROUP |

3. REPORT TITLE

EVALUATION OF NUCLEAR METHODS OF DETERMINING SURFACE IN SITU SOIL WATER CONTENT AND DENSITY

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final report

5. AUTHOR(S) (First name, middle initial, last name)

Thomas B. Rosser III
Steve L. Webster

| 6. REPORT DATE | 7a. TOTAL NO. OF PAGES | 7b. NO. OF REFS |
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10. DISTRIBUTION STATEMENT

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| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY Office, Chief of Engineers, U. S. Army, Washington, D. C. |

13. ABSTRACT

Laboratory tests were conducted to evaluate the accuracy and reliability of measuring surface in situ soil water content and density by the backscatter and direct transmission nuclear methods using a single nuclear device and scaler. The nuclear device functioned as a surface backscatter moisture and density meter or as a direct transmission density probe. To determine the accuracy of the nuclear measurements, it was necessary to know the actual density and water content of the test soil. Boxes were fabricated to exact dimensions, filled with uniformly compacted soil, and weighed, and actual average soil density values were calculated. Five soil types were tested to approximate a full range of possible construction materials. Each soil type was tested at eight different densities and water contents. To obtain comparative results, soil densities of each sample were determined by two accepted conventional methods (sand-cone and water-balloon) for determining density in the field. Test results indicated that in situ densities determined by the direct transmission nuclear method using the factory calibration curve furnished with the device were as accurate as densities obtained by the sand-cone and water-balloon methods. The direct transmission nuclear method using a WES-developed calibration curve provided slightly more accurate density measurements than either conventional method. Densities determined by the surface backscatter nuclear method using both the factory calibration curve and a WES-developed curve were not so accurate as those obtained by the conventional methods. Water contents were obtained by nuclear means and compared with actual water contents determined from ovendried samples. Using a WES-developed calibration curve, water contents obtained by the nuclear method were sufficiently accurate for most quality control fieldwork. Water contents obtained using the factory calibration curve were not accurate enough for field use. A test procedure for determining surface layer density and water content of soil by nuclear methods is presented in Appendix A.

KEYWORDS: Measuring instruments; Nuclear methods; Soil density determination; Water content determination (Soils)

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| 1. ORIGINATING ACTIVITY *(Corporate author)* U. S. Army Engineer Waterways Experiment Station, Vicksburg, Miss. | 2a. REPORT SECURITY CLASSIFICATION: Unclassified |
| | 2b. GROUP |
| 3. REPORT TITLE: A COMPARISON OF ENVIRONMENTS OF RAIN FORESTS IN DOMINICA AND PUERTO RICO | |
| 4. DESCRIPTIVE NOTES *(Type of report and inclusive dates)*: Final report | |
| 5. AUTHOR(S) *(First name, middle initial, last name)*: Mario Soriano-Ressy; A. Paul Desmarais; Jose W. Perez | |
| 6. REPORT DATE: March 1970 | 7a. TOTAL NO. OF PAGES: 36 — 7b. NO. OF REFS: 4 |
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| 11. SUPPLEMENTARY NOTES: *Published in* "The Rain Forest," AEC, 1970. | 12. SPONSORING MILITARY ACTIVITY: U. S. Army Materiel Command, Washington, D. C. |

13. ABSTRACT

Pedologic; geologic; and vegetation taxonomy and structure data were collected from tabonuco forests in Dominica and Puerto Rico to characterize rain forests in the mountains of Caribbean islands. The three Dominica sites were in matured virgin forests; the four Puerto Rico sites were in forests that had been selectively cut. Dominica soils were uniform in profile, consisting largely of volcanic debris subaerially deposited. Soil samples were obtained at 25- to 40-cm depths. pH values were 5.1-5.5. Concentrations of Ca, Mg, K, and Mn, in exchangeable ppm, were 786-800, 498-710, 94-626, and 0-15, respectively. Cation exchange capacities (CEC), in me/100 g, were 15.0-20.5; absolute specific gravities were 2.08-2.27. Puerto Rico soils exhibited A2 and B2 horizons. Generally, the A2 horizon was present to 12-cm depth. The parent material was marine-deposited basalt and tuff breccia. Soil samples were obtained from each horizon. pH values, concentrations of Ca, Mg, and K, and CEC were less than those of the Dominica soils. Absolute specific gravities were about 0.45 higher than those for Dominica samples. Mn concentrations were about the same. Large trees on Puerto Rico sites were smaller than those on Dominica sites, the larger trees being approximately 27 m high and 100-cm DBH. Basal areas computed for trees on Puerto Rico sites were considerably less than for trees on Dominica sites, with values from 0.236% to 0.482%. Graphs relating basal area, plants per unit area, and stem spacing to plant heights are given. Data are compared and interpreted in terms of ecological implications.

KEYWORDS: Comparison; Rain forests; Soil tests; Terrain analysis; Tropical regions; Vegetation structure; [Dominica; Puerto Rico]

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| 1. ORIGINATING ACTIVITY (Corporate author)<br>U. S. Army Engineer Waterways Experiment Station<br>Vicksburg, Mississippi | 2a. REPORT SECURITY CLASSIFICATION<br>Unclassified<br>2b. GROUP | |
| 3. REPORT TITLE<br>WORLDWIDE STRENGTH CONDITIONS OF SURFACE MATERIALS | | |
| 4. DESCRIPTIVE NOTES (Type of report and inclusive dates)<br>Final report | | |
| 5. AUTHOR(S) (First name, middle initial, last name)<br>Marvin P. Meyer<br>William P. Bohnert, Jr. | | |
| 6. REPORT DATE<br>April 1970 | 7a. TOTAL NO. OF PAGES<br>29 | 7b. NO. OF REFS<br>14 |
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| 10. DISTRIBUTION STATEMENT<br>Distribution limited to U. S. Government agencies only; classified reference; 15 November 1971; other requests for this document must be referred to U. S. Naval Weapons Center. | | |
| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY<br>Department of the Navy<br>Naval Weapons Center<br>China Lake, California | |

13. ABSTRACT

Gross surface material strength conditions were mapped on a worldwide basis and more detailed surface strength conditions were mapped for South Vietnam to provide a source of data for design and deployment criteria for missile and munitions systems. The top 15 cm of surface material, including soil, rock, or snow, was mapped in terms of five cone index (CI) classes: >150; 75-150; 45-75; 0-45, soil; and 0-45, snow. Each areal delineation on the map was assigned an average CI class for each of three four-month periods during the year in order to characterize the seasonal climatic effects on soil strength. The world soil strength map is portrayed on a Goode's homolosine projection with an equatorial scale of 1:26,500,000, and the strength map of South Vietnam is portrayed on a Lambert conformal conic projection of approximately 1:1,750,000. Information used for the development of the mapping system was derived from 14 sources of soil strength, state-of-ground, climatic, and soil morphological data. A planimetric analysis of world strength conditions is presented as Appendix A.

KEYWORDS: Snow strength; Soil strength; Soil strength maps; World maps; [South Vietnam]

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| 1. ORIGINATING ACTIVITY (Corporate author)<br>U. S. Army Engineer Waterways Experiment Station<br>Vicksburg, Mississippi | 2a. REPORT SECURITY CLASSIFICATION<br>Unclassified<br>2b. GROUP |

3. REPORT TITLE

AERIAL INFRARED SURVEY OF THE WALTER F. GEORGE LOCK AND DAM
CHATTAHOOCHEE RIVER, ALABAMA-GEORGIA

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
Final report

5. AUTHOR(S) (First name, middle initial, last name)

Lewis E. Link, Jr.

| 6. REPORT DATE | 7a. TOTAL NO. OF PAGES | 7b. NO. OF REFS |
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10. DISTRIBUTION STATEMENT

Approved for Public Release; Distribution Unlimited

| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY |
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| | U. S. Army Engineer District, Mobile |

13. ABSTRACT

A study was made to delineate subsurface seepage channels by infrared scanner imagery at the Walter F. George Lock and Dam, Chattahoochee River, Alabama-Georgia. Ground measurements of the conditions at the site were made to determine the optimum flight time for obtaining the infrared imagery and to aid in interpretation of the imagery. The infrared imagery was collected between 0300 and 0500 hr on 22 November 1969. The imagery was analyzed to determine if any trends existed which might suggest subsurface seepage channels at the site. The ground truth data were used in the imagery interpretation. Interpretation of the infrared imagery did not delineate any trends which indicated paths of flow of the groundwater and reservoir leakage. A study was then made to determine what features affected the tones on the infrared imagery. It was determined that surface features such as grass cover and soil moisture content produced most of the variations in the tone on the infrared imagery. Additional research is recommended in areas where seepage occurs closer to the terrain surface.

KEYWORDS: Aerial surveys; Infrared mapping; Rivers; Seepage; [Walter F. George Lock and Dam]

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3. REPORT TITLE
ENVIRONMENTAL CHARACTERISTICS OF BORDER SECURITY SITES IN PUERTO RICO

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

5. AUTHOR(S) (First name, middle initial, last name)
M. Soriano-Ressy, J. R. Lundien, W. N. Rushing

| 6. REPORT DATE | 7a. TOTAL NO. OF PAGES | 7b. NO. OF REFS |
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| April 1970 | 114 | 0 |

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| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY |
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| | U. S. Army Mobility Equipment Research and Development Center, Fort Belvoir, Virginia |

13. ABSTRACT

Seven areas or sites in Puerto Rico, characteristic of humid tropical environments, were selected as being environmentally representative of (or analogous to) certain regions of interest in Southeast Asia. The sites are covered by mosaics of cultivated fields and wild vegetation, relatively mature forest vegetation, and marshes; and they are situated on a plain, on foothills, and on mountains. The sites were examined in detail under four major areas of investigation: surface composition, surface geometry, vegetation conditions, and meterological characteristics. Information for these major areas of investigation was obtained from various sources including (a) actual field sampling (during the months of August through December), (b) interpretation of air photographs, ground photographs and ground topology and (c) data previously obtained through other programs at TTRD-PR and various other government agencies. The information is presented in the form of verbal descriptions, topographic maps, factor maps, and tabulated data.

KEYWORDS: Border security; Terrain analysis; Terrain factor maps; Tropical regions; [Puerto Rico]

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| 1. ORIGINATING ACTIVITY (Corporate author)<br>U. S. Army Engineer Waterways Experiment Station<br>Vicksburg, Mississippi | 2a. REPORT SECURITY CLASSIFICATION<br>Unclassified<br>2b. GROUP |

3. REPORT TITLE

A PLAN FOR QUANTITATIVE EVALUATION OF THE CROSS-COUNTRY PERFORMANCE OF PROTOTYPE VEHICLES

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final report

5. AUTHOR(S) (First name, middle initial, last name)

Warren E. Grabau
Jack K. Stoll
Beryl G. Stinson

| 6. REPORT DATE | 7a. TOTAL NO. OF PAGES | 7b. NO. OF REFS |
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| c. ARPA Order No. 400 | 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)<br>AD 877 016 |
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| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY<br>U. S. Army Materiel Command<br>Washington, D. C. |

13. ABSTRACT

A method of evaluating the cross-country performance of vehicles using quantitative descriptions of the terrain and a mathematical model that relates terrain parameters to vehicle performance is presented. A delivery index equation is introduced that gives a measure of cargo delivery over a specified terrain for a specified mission considering speed made good, loading and unloading time, servicing time, cruising range, and cargo capacity. The vehicle performance evaluation procedures are illustrated by applying them in a comparative analysis of the M37 and XM561 cargo trucks traversing selected terrains in the vicinity of Khon Kaen, Thailand. Quantitative terrain maps and mobility maps (in terms of speed made good) that were used to evaluate the relative performances of the M37 and XM561 are included. Appendixes present a tentative selection of "standard terrains" that could be used in evaluating relative performances of vehicles and a first-generation computer program for predicting speed performance. It is recommended that research be continued to improve the reliability and scope of the mathematical model for predicting vehicle performance and that areas of the world be selected and mapped as standard terrains for use as performance evaluation bases.

KEYWORDS: Computerized models; Military vehicles; Mobility models; Offroad mobility; Performance predictions; Terrain factor maps

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| 1. ORIGINATING ACTIVITY (Corporate author)<br>U. S. Army Engineer Waterways Experiment Station<br>Vicksburg, Mississippi | 2a. REPORT SECURITY CLASSIFICATION<br>Unclassified<br>2b. GROUP |

3. REPORT TITLE

THE EFFECTS OF GEOLOGICAL FEATURES ON SOIL STRENGTH

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
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5. AUTHOR(S) (First name, middle initial, last name)

Ellis L. Krinitzsky

| 6. REPORT DATE | 7a. TOTAL NO. OF PAGES | 7b. NO. OF REFS |
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| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY<br>Assistant Secretary of the Army (R&D)<br>Department of the Army<br>Washington, D. C. |

13. ABSTRACT

X-ray examinations of fine-grained soils from the Lower Mississippi Valley revealed numerous geologic features that are not visible to the unaided eye. These features include significant fracture patterns, details of planar bedding, cross-laminations and turbulence, secondary mineralizations, root penetrations and voids left by roots, the presence of disseminated organic matter, and other details. These geologic features affect the strength properties of the soils in which they occur. Experiments with multiple specimens from single samples embodying different features demonstrated that many large variations in strength properties were not only directly dependent on these features but were predictable in a relative sense. Normally, these features are never identified during routine soils testing although the effects of these features contribute to erratic test results. Pretest radiographic examination is a potential means of avoiding these problems.

KEYWORDS: Fine grained soils; Laboratory tests; Soil properties; Soil strength; X-rays; [Lower Mississippi Valley]

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| 1. ORIGINATING ACTIVITY (Corporate author)<br>U. S. Army Engineer Waterways Experiment Station<br>Vicksburg, Mississippi | 2a. REPORT SECURITY CLASSIFICATION<br>Unclassified<br>2b. GROUP |

3. REPORT TITLE
STANDARD PENETRATION TEST AND RELATIVE DENSITY

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
Final report

5. AUTHOR(S) (First name, middle initial, last name)
Klaus-Jurgen Melzer

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| 6. REPORT DATE<br>February 1971 | 7a. TOTAL NO. OF PAGES<br>10 | 7b. NO. OF REFS<br>15 |

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| 11. SUPPLEMENTARY NOTES Paper to be presented at Fourth Pan American Conference on Soil Mechanics and Foundation Engineering, San Juan, Puerto Rico, 14-18 June 1971, Proceed., Vol II. | 12. SPONSORING MILITARY ACTIVITY<br>U. S. Army Materiel Command<br>Washington, D. C. |

13. ABSTRACT

Since ground water greatly influences penetration resistance of soil, an empirical relation was established between the number of blows applied in the standard penetration test to sand below ground-water level and the corresponding number applied to air-dry sand at the same relative density. Also, since the number of blows was found to depend not only on the relative density but also on the compactibility and the grain size of the penetrated sand, an empirical relation was developed between the number of blows and the relative density, with compactibility and mean grain diameter taken into account. This relation was verified by results from laboratory tests conducted with a small static penetrometer.



KEYWORDS: Penetrometers; Sands; Soil density; Soil density measuring devices; Soil penetration tests; Unit weight determination


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| 1. ORIGINATING ACTIVITY (Corporate author)<br>U. S. Army Engineer Waterways Experiment Station<br>Vicksburg, Mississippi | 2a. REPORT SECURITY CLASSIFICATION<br>Unclassified<br>2b. GROUP |

3. REPORT TITLE

EVALUATING PENETRATION TESTS IN CLAY FROM MEASURED SOIL PARTICLE MOVEMENTS

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

5. AUTHOR(S) (First name, middle initial, last name)

Y. T. Chou

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| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY |
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| | U. S. Army Materiel Command<br>Washington, D. C. |

13. ABSTRACT

The deformation and flow characteristics of a near-saturated fat clay under penetration were studied. Penetrations were made in a 50.8-cm-diam mold with a circular cone, a circular plate, and two rectangular plates at speeds ranging from 0.004 to 5.6 cm/sec. The strain, strain rate, and velocity fields in the soil were calculated from the soil particle movements, determined by measuring the displacement of pellets embedded in the soil before penetration. Actual soil flow patterns determined from velocity fields were studied. It was found that if the deformation energy of the soil were assumed equal to the penetration energy, the former could be obtained by integration over the affected volume of the deformed soil. The penetration resistance was thus computed on the basis of the Von Mises yield criterion and compared with the measured penetration resistance. Computed and measured penetration resistance values were markedly different; this casts some doubt on the applicability of the Von Mises equation to results of tests on clay under penetration and on the computational procedure employed.

KEYWORDS: Clays; Laboratory tests; Penetration resistance (Soils); Penetrometers; Soil penetration tests

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3. REPORT TITLE
EVENT DIAL PACK; PROJECT LN309: EFFECTIVENESS OF CRATERS AS BARRIERS TO MOBILITY

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
Final report

5. AUTHOR(S) (First name, middle initial, last name)
Claude A. Blackmon
Adam A. Rula

| 6. REPORT DATE | 7a. TOTAL NO. OF PAGES | 7b. NO. OF REFS |
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10. DISTRIBUTION STATEMENT
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| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY |
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| Published in Event Dial Pack Symposium Report, Vol II, Project LN 309, Mar 1971. | Defense Atomic Support Agency<br>Washington, D. C. |

13. ABSTRACT

Event Dial Pack, a 500-ton spherical TNT charge tangent to ground surface, was detonated on 23 July 1970 at the Defence Research Establishment, Suffield (DRES), Ralston, Alberta, Canada. Project LN309: "Effectiveness of Craters as Barriers to Mobility," was included in the program of United States sponsored projects pertaining to the event. The objective of Project LN309 was to determine the degree to which a crater and its associated ejecta field constitute a physical barrier to the movement of military vehicles. Four terrain units in the crater and ejecta area were delineated as significant to ground mobility and described in terms of soil strength, soil moisture content, surface configuration, ejecta depth, and areal extent. Performance test data obtained with an M37 3/4-ton truck and an M113A1 armored personnel carrier were used to determine performance degradation in each terrain unit. Vehicle performance in the terrain units identified was predicted using the necessary elements of the Waterways Experiment Station analytical model for predicting off-road vehicle performance, and measured and predicted values for four performance parameters (drawbar pull, go-no go, motion resistance, and speed) were compared. The accuracy of the predictions was acceptable for all performance parameters except that the speeds predicted for the terrain unit (outer lip) that provided the least resistance to motion were higher than the measured values.

KEYWORDS: Crater ejecta; Craters; Explosion effects; Military vehicles; Mobility; Obstacles; Performance predictions; Personnel carriers; Terrain analysis; Trucks; [Dial pack (Event)]

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| 1. ORIGINATING ACTIVITY (Corporate author)<br>U. S. Army Engineer Waterways Experiment Station<br>Vicksburg, Mississippi | 2a. REPORT SECURITY CLASSIFICATION<br>Unclassified<br>2b. GROUP |

3. REPORT TITLE
UTILIZATION OF SYNTHETIC SOILS IN ENGINEERING RESEARCH

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
Final report

5. AUTHOR(S) (First name, middle initial, last name)
Andrew J. Green

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| 6. REPORT DATE<br>June 1971 | 7a. TOTAL NO. OF PAGES<br>20 | 7b. NO. OF REFS<br>6 |
| 8a. CONTRACT OR GRANT NO.<br>b. PROJECT NO. 4A061101A91D<br>c.<br>d. | 9a. ORIGINATOR'S REPORT NUMBER(S)<br>Miscellaneous Paper M-71-5<br>9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)<br>AD A006 519 | |

10. DISTRIBUTION STATEMENT
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| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY<br>Assistant Secretary of the Army (R&D), Department of the Army, Washington, D. C. |

13. ABSTRACT

This report summarizes published results and personal comments of a number of researchers who have used synthetic soil mixtures. It also contains a small amount of data collected at the Waterways Experiment Station. In general, it can be said that whereas synthetic soils may be useful in some limited sense, they do not offer the panacea that earlier researchers claimed or hoped for. The engineering properties of many synthetic mixes may be more dependent on temperature and rate of loading than those of soil-water mixes. It is concluded that the usefulness of synthetic soils in engineering research is rather limited, and it is recommended that any researcher thoroughly study the behavioral patterns peculiar to a particular synthetic mix he may plan to use lest the utility of the information produced be restricted by them.

KEYWORDS: Engineering research; State-of-the-art studies; Synthetic soils

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| 1. ORIGINATING ACTIVITY (Corporate author)<br>U. S. Army Engineer Waterways Experiment Station<br>Vicksburg, Mississippi | 2a. REPORT SECURITY CLASSIFICATION<br>Unclassified<br>2b. GROUP |

3. REPORT TITLE

REPORT OF CONFERENCE ON SEISMIC PROPAGATION STUDY, U. S. Army Engineer Waterways Experiment Station, 22 June 1971

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

5. AUTHOR(S) (First name, middle initial, last name)

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| 6. REPORT DATE | 7a. TOTAL NO. OF PAGES | 7b. NO. OF REFS |
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| August 1971 | 113 | |

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| 8a. CONTRACT OR GRANT NO.<br>b. PROJECT NO. 4A062112A854<br>Terrestrial Investigations<br>c.<br>d. | 9a. ORIGINATOR'S REPORT NUMBER(S)<br>Unnumbered<br>9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)<br>AD 755 909 |

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| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY |
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| | Office, Chief of Engineers, Department of the Army, Washington, D. C. |

13. ABSTRACT

This report summarizes the discussions in a meeting held at the U. S. Army Engineer Waterways Experiment Station on 22 June 1971 to review the progress of the Seismic Propagation Study and to afford an opportunity for comments and recommendations for future work. Information is presented on subjects as follows: theoretical studies (Dr. H. Nikodem); program objectives, avenues of approach and relations to other sensor studies (B. O. Benn); environmental data of the seismic sensor system (H. K. Woods); seimic response measurements and results (R. F. Ballard); instrumentation display and demonstration (L. E. Link and M. B. Savage); and empirical studies (Dr. W. F. Marcuson).

KEYWORDS: Meetings; Seismic investigations; Seismic sensors; State-of-the-art studies

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| 1. ORIGINATING ACTIVITY (Corporate author)<br>U. S. Army Engineer Waterways Experiment Station<br>Vicksburg, Mississippi | 2a. REPORT SECURITY CLASSIFICATION<br>Unclassified<br>2b. GROUP |

3. REPORT TITLE
AUTOMATION OF MODEL FOR PREDICTING THE CLEARING OF VEGETATION BY EXPLOSIVES FOR HELICOPTER LANDING ZONES (HLZ MODEL)

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

5. AUTHOR(S) (First name, middle initial, last name)
M. H. Smith

| 6. REPORT DATE | 7a. TOTAL NO. OF PAGES | 7b. NO. OF REFS |
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| March 1972 | 137 | 4 |

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| 8a. CONTRACT OR GRANT NO.<br>b. PROJECT NO. 4A663712D860<br>c. Task 04, MGI Data Base<br>d. Work Unit 04, Automation of Performance Prediction models | 9a. ORIGINATOR'S REPORT NUMBER(S)<br>Miscellaneous Paper No. M-72-1<br>9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)<br>AD B007 718L |

10. DISTRIBUTION STATEMENT
Distribution limited to U. S. Government agencies only; test and evaluation; March 1972. Other requests for this document must be referred to the U. S. Army Engineer Waterways Experiment Station.

| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY |
|---|---|
| | U. S. Army Engineer Topographic Laboratories, Fort Belvoir, Virginia |

13. ABSTRACT
The HLZ model predicts the geometry of a clearing in a wooded area that has been produced by an explosive and evaluates the clearing for use as a landing zone for the Huey and/or Chinook helicopters. The model solves one of two problem types: (a) Finds the size bomb required to clear an area for a nontouch, skid, or full-touch landing by the helicopter, (b) Evaluates the clearing made by a given bomb for a nontouch, skid, or full-touch landing by the Huey or Chinook helicopter. The model is a mathematical presentation of a nomograph developed from the relation of tree strength (as determined from Young's modulus, the modulus of rupture and tree density) and the dynamic pressure impulse of a given bomb's explosive force upon the tree at a given distance from the explosion center. The program for the model is written in Fortran IV conversational mode for use on a teletype connected to a General Electric 435 computer. One of two levels of input data is acceptable by the program, a set of specific data or a set of data based on class estimates. An alternate program is provided that includes subroutines to generate a plot tape for producing graphs of tree remnant heights versus distance from explosion center. A schematic showing the flow of logic, a detailed flow chart, and example solutions are included in Appendix A of this report.

KEYWORDS: Computerized models; Helicopter landing zones; Munition effectiveness; Vegetation clearing

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| 1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Miss. | 2a. REPORT SECURITY CLASSIFICATION Unclassified; 2b. GROUP |
| 3. REPORT TITLE EFFECTS OF ENVIRONMENT ON SEISMIC INTRUSION DETECTOR PERFORMANCE; A PRELIMINARY REPORT | |
| 4. DESCRIPTIVE NOTES (Type of report and inclusive dates) Preliminary report | |
| 5. AUTHOR(S) (First name, middle initial, last name) Bob O. Benn; Lewis E. Link | |
| 6. REPORT DATE April 1972 | 7a. TOTAL NO. OF PAGES 50; 7b. NO. OF REFS 21 |
| 8a. CONTRACT OR GRANT NO.; b. PROJECT NO.; c. Task 11860040006; d. | 9a. ORIGINATOR'S REPORT NUMBER(S) Miscellaneous Paper M-72-4; 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) AD 894 404 |
| 10. DISTRIBUTION STATEMENT Approved for public release; distribution unlimited. | |
| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY U. S. Army Engineer Topographic Laboratories Fort Belvoir, Virginia |

13. ABSTRACT

Improved guidance manuals for planning the deployment and emplacement of seismic intrusion detectors (SID's) are needed to optimize the use of these devices for battlefield surveillance. The development of these Military Geographic Intelligence (MGI) products requires a detailed understanding of the operating principles of the detector coupled with an equally detailed understanding of the interactions of the sensor propagation mode with the operational environment. This report presents the results of a preliminary analysis of data collected in a wide range of environments at 22 sites in Panama, 10 sites in Puerto Rico, 6 sites near Yuma Proving Ground, Arizona, and 9 sites near Ft. Huachuca, Arizona. Multiple regression techniques were used to determine the terrain factors that could be correlated with the seismic responses resulting from a man walking or a controlled source (drop hammer) that simulated the signature resulting from a footstep. The measure of seismic response was peak particle velocity as a function of distance from the source. The terrain factors that correlated best with peak particle velocity were the thickness of the first refraction layer, cone index of the 0- to 15-cm soil layer, dry density of surface soil and first soil layer, water content of surface soil and first soil layer, compression wave velocity, Rayleigh wave velocity, and grain-size distribution. An empirical equation was developed to predict peak particle velocity versus distance as a function of the terrain factors. The particle velocities required to trigger the logic of the Phase III SID's were superimposed on the predicted peak particle velocity curves to arrive at a prediction of sensor performance. These computation procedures were computerized to make a prediction model for relative SID performance as a function of terrain factor values. The empirical prediction equation adequately predicted the peak particle distance relation; however, the predictions of sensor performance were inadequate. The errors in the predictions of sensor performance were attributed to the inadequacy of the peak particle velocity-distance relation to represent the complex interaction of the entire seismic signal and the sensor. Frequency characteristics of the seismic signal and the frequency response characteristics of the sensors also must be considered.

KEYWORDS: Desert regions; Environmental effects; Military bases; Performance predictions; Seismic sensors; Tropical regions; [Ft. Huachuca, Arizona; Panama; Puerto Rico; Yuma, P.G. Arizona]

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U. S. Army Engineer Waterways Experiment Station
Vicksburg, Mississippi

2a. REPORT SECURITY CLASSIFICATION

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3. REPORT TITLE

REPORT OF SECOND CONFERENCE ON SEISMIC PROPAGATION STUDY, U. S. Army Research Office, 15 December 1971

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

5. AUTHOR(S) (First name, middle initial, last name)

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10. DISTRIBUTION STATEMENT

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11. SUPPLEMENTARY NOTES

12. SPONSORING MILITARY ACTIVITY

Office, Chief of Engineers, U. S. Army

13. ABSTRACT

This report summarizes the discussions in a second meeting held at the Army Research Office on 15 December 1971 to review the progress of the Seismic Propagation Study and to afford an opportunity for comments and recommendations for future work. Information is presented on subjects as follows: program background and related programs at WES (B. O. Benn); empirical studies (L. E. Link); theoretical studies (Dr. H. Nikodem); modeling sensor characteristics (J. R. Lundien); terrain models and sensor performance mapping (J. H. Shamburger); terrain models (frost-thaw-snow) (F. E. Crory); mapping background noise, experimental program (R. F. Ballard); and summary of proposed work (B. O. Benn).

KEYWORDS: Meetings; Seismic investigations; Seismic sensors; State-of-the-art studies

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| 1. ORIGINATING ACTIVITY (Corporate author)<br>U. S. Army Engineer Waterways Experiment Station<br>Vicksburg, Mississippi | 2a. REPORT SECURITY CLASSIFICATION<br>Unclassified<br>2b. GROUP |

3. REPORT TITLE

A METHOD FOR PRODUCING QUANTITATIVELY BASED MILITARY GEOGRAPHIC INTELLIGENCE PRODUCTS FOR AN AIRMOBILE DIVISION

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final report

5. AUTHOR(S) (First name, middle initial, last name)

Joseph L. Decell
Warren E. Grabau
Bob O. Benn
Jack K. Stoll
Beryl G. Stinson

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| 8a. CONTRACT OR GRANT NO.<br>b. PROJECT NO.<br>c. Intra-Army Order No. MERDC 194.69, Task 9860032<br>d. | 9a. ORIGINATOR'S REPORT NUMBER(S)<br>Miscellaneous Paper M-72-6<br>9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)<br>AD 756 191 |

10. DISTRIBUTION STATEMENT

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| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY<br>U. S. Army Engineer Topographic Laboratories<br>Fort Belvoir, Virginia |

13. ABSTRACT

Seven prototype military geographic intelligence (MGI) products, specifically designed to meet the terrain intelligence needs of an airmobile division in a tactical situation, were developed. The development included five steps: (1) compilation of conceptual models relating the terrain to certain tactical activities; (2) identification of significant terrain factors and assignment of class ranges of their values on the basis of the requirements of the models; (3) construction of factor maps of the selected study area on the basis of the selected terrain factor classes; (4) compilation of a factor complex map for each desired MGI product; and (5) transformation of the factor complex maps to "performance prediction" maps, which were the desired end product. Schematic flow charts of the models are presented, together with lists of significant factors, tables defining classifications of factor values, and the entire array of factor maps, factor complex maps, and MGI products maps.

KEYWORDS: Airmobile operations; Military geographic intelligence; Terrain analysis; Terrain factor maps; Terrain models (Analytical)

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| 1. ORIGINATING ACTIVITY (Corporate author)<br>U. S. Army Engineer Waterways Experiment Station<br>Vicksburg, Mississippi | 2a. REPORT SECURITY CLASSIFICATION<br>Unclassified<br>2b. GROUP |

3. REPORT TITLE

A SYSTEM FOR MEASURING TREE OR STAND PRODUCTIVITY FOR USE IN THE MANAGEMENT OF FOREST LANDS

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final Report

5. AUTHOR(S) (First name, middle initial, last name)

Hollis H. Allen
Harold W. West

| 6. REPORT DATE | 7a. TOTAL NO. OF PAGES | 7b. NO. OF REFS |
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| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY |
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| Presented at 45th Annual Meeting of NW Scientific Assn., W. Washington State Coll., 23-25 Mar 1972. | |

13. ABSTRACT

The U. S. Army Engineer Waterways Experiment Station has developed and evaluated a nondestructive system for describing the three-dimensional geometry of trees and stands. Tree or stand productivity was determined by dimensioning (i.e. measuring) the trees (or stands) before the start of a growing season and again after the growing season was completed. A measure of productivity was established by calculating the change or increase in tree height, stem and branch diameters, and wood volumes for each tree. This system has demonstrated that significant changes in tree productivity during one season's growth can be detected between untreated stands and ones subjected to fertilizer treatments, thus making it an invaluable tool for management of forest stands.

KEYWORDS: Trees; Vegetation structure

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| 1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Mississippi | | 2a. REPORT SECURITY CLASSIFICATION Unclassified<br>2b. GROUP |
| 3. REPORT TITLE GROUND TRUTH REQUIREMENTS FOR REMOTE SENSOR DATA ACQUISITION AND ANALYSIS | | |
| 4. DESCRIPTIVE NOTES (Type of report and inclusive dates) Final report | | |
| 5. AUTHOR(S) (First name, middle initial, last name) Lewis E. Link, Jr. | | |
| 6. REPORT DATE November 1972 | 7a. TOTAL NO. OF PAGES 43 | 7b. NO. OF REFS 13 |
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| 10. DISTRIBUTION STATEMENT Approved for public release; distribution unlimited. | | |
| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY U. S. Army Engineer Topographic Laboratories Fort Belvoir, Virginia | |

13. ABSTRACT

Over the past few years airborne remote sensor devices have been developed for different regions of the electromagnetic spectrum that are capable of collecting data on the reflective and emissive properties of terrain. However, experience has shown that the capability to collect data of this type is not, in itself, sufficient to permit its fullest use. In almost every case, data collected with an airborne electromagnetic sensing system (remote sensor) must be augmented by data that define conditions existing in the environment at the time the remote sensor was used. The environmental factors that influence the electromagnetic energy received by remote sensing devices are defined for the following spectral regions: (a) gamma ray, (b) ultraviolet, (c) visible, (d) infrared, and (e) microwave. In addition, the remote sensing devices utilized in each spectral region are discussed and the environmental factors appraised for relative importance with respect to the final remote sensing product. The relative importance of the environmental factors may change with the purposes of remote sensing surveys; however, it is beyond the scope of this report to document the relative importance of environmental factors for each specific purpose.

KEYWORDS: Airborne equipment; Electromagnetic sensors; Environmental factors; Remote sensing

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| 1. ORIGINATING ACTIVITY (Corporate author)<br>U. S. Army Engineer Waterways Experiment Station<br>Vicksburg, Mississippi | 2a. REPORT SECURITY CLASSIFICATION<br>Unclassified<br>2b. GROUP |

3. REPORT TITLE

OVERT ECOLOGIC EFFECTS OF EJECTA FROM NUCLEAR EXCAVATION, PROPOSED INTEROCEANIC CANAL ROUTE 25

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final Report

5. AUTHOR(S) (First name, middle initial, last name)

Eugene E. Addor

| 6. REPORT DATE | 7a. TOTAL NO. OF PAGES | 7b. NO. OF REFS |
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| 8a. CONTRACT OR GRANT NO. | 9a. ORIGINATOR'S REPORT NUMBER(S) |
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| c. Intra-Army Order 08-123 ENG-118-70 | 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) |
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10. DISTRIBUTION STATEMENT

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| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY<br>Office, Chief of Engineers, U. S. Army<br>Washington, D. C. |

13. ABSTRACT A study was made to identify the ecological relations that would be affected by nuclear excavation of the proposed sea-level interoceanic canal, and to predict, generally, the response of the ecosystems to the expected perturbations. The western portion of proposed route 25 was selected for study, but the prediction methods can be applied generally to any area. Ejecta depth and dispersal patterns are predicted; they are related to (a) existing topography in order to predict postexcavation topography and its ecological relations, and (b) existing vegetation in order to predict the direct destruction and subsequent recovery and regeneration of plant cover. Postexcavation topography is predicted to be characterized by 500-ft-high continuous ridges bounding both sides of the canal. These ridges will have steep slopes into and relatively gentle slopes away from the canal, phasing out and interfingering with the discontinuous ejecta zone about 1/2 to 1-1/2 miles from the canal center line. These ridges will intercept several large streams and numerous lesser drainages. Numerous small to large artificial lakes will form. Calculations indicate that the 16-square-mile Mercua Valley may be inundated. Tall forests dominate the region. Depth and fragmentation characteristics of the ejecta in the continuous ejecta zone virtually preclude survival of any forest to a distance of 3/4 to 1 mile from the canal (about 40 square miles). Surface characteristics of this area may preclude reforestation by natural means. Commercially useful species might be established by planting, but it appears likely that the area would remain a wasteland for a long time. Within the continuous ejecta zone, animal life will be destroyed. The present kinds of habitats probably will not be regenerated, and the area will be reoccupied by a different fauna. The discontinuous ejecta zone will extend 3 miles or more beyond the continuous ejecta zone, but the spatial frequency and size of fragments will diminish rapidly with increasing distance. Close in, extensive damage to forests may be expected from direct bombardment and downslope movement of fragments after initial impact; accumulation of fragments in valley bottoms will probably produce numerous pools and rapids in streams, but will not produce many lakes of significant size. Effects from fragments will be negligible beyond about 2 miles. Thus, a 1-mile-wide band beyond the continuous ejecta zone on both sides of the canal may be seriously affected by fragments. No serious threat to the near-surface groundwater regime nor to deep groundwater by saltwater intrusion is apparent. Extensive sedimentation may occur since the area has intensive rainfall, and most of the ejecta area will be drained into the canal. Sedimentation and hydraulic mechanisms within the navigation channel are discussed.

KEYWORDS: Crater ejecta; Environmental effects; Nuclear excavation

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| 3. REPORT TITLE<br>NOTES ON PROVING RINGS AND FRAMES FOR SOIL TESTING EQUIPMENT | |
| 4. DESCRIPTIVE NOTES (Type of report and inclusive dates)<br>Final report | |
| 5. AUTHOR(S) (First name, middle initial, last name)<br>Mikael J. Hvorslev | |
| 6. REPORT DATE<br>March 1972 | 7a. TOTAL NO. OF PAGES<br>46<br>7b. NO. OF REFS<br>5 |
| 8a. CONTRACT OR GRANT NO.<br>b. PROJECT NO.<br>c.<br>d. | 9a. ORIGINATOR'S REPORT NUMBER(S)<br>Miscellaneous Paper S-72-9<br>9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)<br>AD 756 199 |
| 10. DISTRIBUTION STATEMENT<br>Approved for public release; distribution unlimited. | |
| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY<br>Office, Chief of Engineers<br>Washington, D. C. |

13. ABSTRACT

This report presents data on the design, construction, and calibration of various types of proving rings and frames used for determination and direct readout of forces or loads in laboratory and field tests on soils and other relatively weak materials. The first part of the report presents equations and diagrams for determination of deflections and moments in thin circular rings, ring segments with bosses, elliptical rings, flattened rings, rectangular proving frames with thin or thick end sections, and compound cantilevers. Some of these equations can be found in handbooks and textbooks, but other equations are not readily available and were developed by applying standard methods of the theory of elasticity to relatively thin structures. The second part of the report deals with the influence of several secondary factors, such as large deformations which can cause appreciable curvature of the calibration diagrams. Rigorous equations for thick rings yield data on corrections for relatively thick devices. Empirical data on fillets and stress concentrations are presented, and the approximate stiffening effect of fillets is estimated by use of a simplified theory in which only angular deflections caused by moments are considered. The influence of misalignment, creep and hysteresis, and temperature variations is discussed briefly. The last two parts of the report present examples of single and compound proving rings and frames proposed for use or actually used in testing equipment. General design procedures using the basic equations are proposed, and data are presented on suitable materials, including recent alloy steels capable of age or precipitation hardening, which eliminates the distortion often caused by heat treatment and quenching of other steels. The final sections deal with rough calibration before hardening and final machining and corrections of dimensions if needed, which are followed by repetitive loading to slightly above the rated capacity before the final calibration in order to decrease the effects of hysteresis and creep and the possibility of zero shifts.

KEYWORDS: Penetrometers; Soil strength test instruments

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| 1. ORIGINATING ACTIVITY (Corporate author)<br>U. S. Army Engineer Waterways Experiment Station<br>Vicksburg, Mississippi | 2a. REPORT SECURITY CLASSIFICATION<br>Unclassified<br>2b. GROUP |

3. REPORT TITLE

AUTOMATION OF A MODEL FOR PREDICTING SOIL MOISTURE AND SOIL STRENGTH (SMSP MODEL)

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final report

5. AUTHOR(S) (First name, middle initial, last name)

Margaret H. Smith
Marvin P. Meyer

| 6. REPORT DATE | 7a. TOTAL NO. OF PAGES | 7b. NO. OF REFS |
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| d. Work Unit 04 | AD 755 095 |

10. DISTRIBUTION STATEMENT

Approved for public release; distribution unlimited.

| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY |
|---|---|
| | U. S. Army Engineer Topographic Laboratories<br>Fort Belvoir, Virginia |


13. ABSTRACT The soil moisture strength prediction (SMSP) model is a composite of the methods developed at the U. S. Army Engineer Waterways Experiment Station for predicting daily soil moisture contents and strengths (in terms of cone index and rating cone index) of soil layers at depths of 0-15 and 15-30 cm. Information required by the model includes soil moisture accretion and depletion relations, field maximum and minimum soil moisture contents, moisture content at start of prediction, soil dry density, soil moisture-strength relation, daily rainfall amounts, and minimum rainfall amount required for accretion. This information can be obtained from one or more of three sources: (a) directly from measurements at a specific location; (b) indirectly from estimated or averaged data derived from field measurements, literature, or empirical equations built into the model; or (c) indirectly from a surface composition group classification that closely follows the Unified Soil Classification System. The computer program for the model is written in Fortran IV conversational mode for use on a teletype connected to a Honeywell-GE (General Electric) 440 computer. Output data are stored in permanent files for use by other performance prediction models, for printing, or for input to plotting programs. The main text of the report includes a discussion of the structure, operation, use, limitations, and mathematics of the model. Appendixes A-G include detailed flow charts and listings of the computer program; listings, organization, and format of input data; examples of prediction runs and graphic displays of results; and procedures for converting output data to terms required by the airfield construction effort model.



KEYWORDS: Computerized models; Soil moisture prediction; Soil strength prediction; Terrain models (Analytical)


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| 1. ORIGINATING ACTIVITY (Corporate author)<br>U. S. Army Engineer Waterways Experiment Station<br>Vicksburg, Mississippi | 2a. REPORT SECURITY CLASSIFICATION<br>Unclassified<br>2b. GROUP |

3. REPORT TITLE

SITE CHARACTERIZATION OF VEHICLE SIGNATURE STUDY SITES, GENERAL MOTORS PROVING GROUNDS, MILFORD, MICHIGAN

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final report

5. AUTHOR(S) (First name, middle initial, last name)

Joseph R. Curro, Jr.

| 6. REPORT DATE | 7a. TOTAL NO. OF PAGES | 7b. NO. OF REFS |
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| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY |
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| | U.S. Army Materiel Command<br>Washington, D. C., and<br>U.S. Army Tank-Automotive Command<br>Warren, Michigan |

13. ABSTRACT

An environmental characterization of two test sites to be used by TACOM for vehicle signature studies was conducted at the General Motors Proving Grounds, Milford, Michigan, during July and August 1972. Each test site consisted of a roadway (paved or unpaved) and the adjacent in situ soil surface. Detailed seismic data on compression- and shear-wave velocities, depth of interfaces, shear and compression moduli, and Poisson's ratio were determined, as were conventional environmental data consisting of topographic description and such soil parameters as wet density, moisture content, cone index, and soil particle size and type. The results indicated the compression- and shear-wave velocities in the near-surface material (0-1.0 m) to be significantly greater for the roadways than for the in situ soil. The shear and Young's moduli follow the same trends as the velocities. Values of Poisson's ratio exhibited considerable variation above the 1.0-m depth, but were almost constant at depths below 1.0 m for individual locations. Values of wet density and cone index were greater for the surface of the roadways than for the in situ soil. The maximum value of cone index (750+ psi) was obtained at depths not exceeding 30.5 cm. Moisture content values ranged from 0.7 to 14.4 percent, with no depth correlation. Seven soil types (SM, SP, SW-SM, SM-SC, GP, SP-SM, and CL) occur at site 1 and six types (SM, SP, GP, SW, GM-GC, and GW-GM) at site 2. The terrain surface at site 1 is undulating; the paved roadway is almost level. The land surface at site 2 dips gradually to the south with no extreme elevation changes.

KEYWORDS: Roads; Seismic investigations; Soil properties; Vehicle signature; [General Motors Proving Grounds, Milford, Michigan]

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| 1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Miss. | 2a. REPORT SECURITY CLASSIFICATION Unclassified |
| | 2b. GROUP |

3. REPORT TITLE

EVENT MIXED COMPANY III; PROJECT LN305: EFFECTIVENESS OF CRATERS AS BARRIERS TO MOBILITY

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final report

5. AUTHOR(S) (First name, middle initial, last name)

Charles E. Green

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| c. Work Unit 002 | 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) |
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10. DISTRIBUTION STATEMENT

**Approved for public release; distribution unlimited.**

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| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY Defense Nuclear Agency Washington, D. C. |

13. ABSTRACT

Event Mixed Company III, a 500-ton TNT surface charge, was detonated on 13 November 1972 at Grand Junction, Colorado, near Glade Park. Project LN305, "Effectiveness of Craters as Barriers to Mobility," was included in the program of projects sponsored by the United States pertaining to the event. The objective of Project LN305 was to determine: (a) the degree to which a crater and its associated ejecta field constitute a physical barrier to the movement of military vehicles, and (b) if the crater was impassable, the amount of engineering effort required to construct a passable route for the vehicles under consideration. Five terrain units (including the original surface) in the crater area were delineated as significant to ground mobility and were described in terms of soil strength, soil moisture content, surface configuration, and ejecta depth. Go-no go mobility tests were conducted with two tracked vehicles (an M113A1 armored personnel carrier and an M60A1 tank) and one wheeled vehicle (an M561 1-1/4-ton cargo carrier). The vehicles were operated easily in all the terrain units except terrain unit 4, the crater wall. The crater wall of test lane B was impassable for all the vehicles until the steep slope (66 percent) was graded to a 47 percent slope. The grading required 12 minutes with a TD 20 bulldozer. All vehicles experienced approximately the same degree of difficulty negotiating the crater walls (terrain unit 4).

KEYWORDS: Crater ejecta; Craters; Engineering effort; Explosion effects; Field tests; Military vehicles; Mobility; Terrain analysis; [M60A1 tank; M113A1 carrier; M561 carrier; Mixed Company III (Event)]; obstacles

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3. REPORT TITLE

PROJECT DIAMOND ORE; PHASE IIA: EFFECTIVENESS OF CRATERS AS BARRIERS TO MOBILITY

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final report

5. AUTHOR(S) (First name, middle initial, last name)

Claude A. Blackmon
Charles E. Green

| 6. REPORT DATE | 7a. TOTAL NO. OF PAGES | 7b. NO. OF REFS |
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10. DISTRIBUTION STATEMENT

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| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY<br>Office, Chief of Engineers, U. S. Army<br>Washington, D. C. |

13. ABSTRACT

Project DIAMOND ORE Phase IIA consisted of the detonation of three 10-ton charges of aluminized ammonium nitrate slurry at different depths of burst (DOB) and stemming conditions near Fort Peck, Montana, in October 1972. The purpose of the investigation described herein was to determine the effectiveness of the three craters as barriers to the performance of an M48A2 tank. The unstemmed charge at optimum DOB that formed crater IIA-1 created a marginal condition of "go-no go" for the tank. The stemmed charge at optimum DOB that formed crater IIA-2 and the stemmed charge at approximately one-half optimum DOB that formed crater IIA-3 created definite barriers to the tank. There were indications that a more effective barrier for the tank was produced by the stemmed charge at approximately one-half optimum DOB than by the stemmed charge at optimum DOB. The time required for a D-9 tractor to make crater IIA-3 passable for the M48A2 tank was 1 hour.

KEYWORDS: Craters; Explosion effects; Military vehicles; Mobility; Obstacles; Tanks (Combat vehicles); [Diamond Ore (Project); M48A2 tank]

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| 1. ORIGINATING ACTIVITY *(Corporate author)*<br>U. S. Army Engineer Waterways Experiment Station<br>Vicksburg, Mississippi | 2a. REPORT SECURITY CLASSIFICATION<br>Unclassified<br>2b. GROUP |
| 3. REPORT TITLE<br>ANALYSIS OF THE ABILITY OF A LASER PROFILOMETER SYSTEM TO EVALUATE UNPREPARED LANDING SITES | |
| 4. DESCRIPTIVE NOTES *(Type of report and inclusive dates)*<br>Final report | |
| 5. AUTHOR(S) *(First name, middle initial, last name)*<br>Lewis E. Link, Jr. | |

| 6. REPORT DATE | 7a. TOTAL NO. OF PAGES | 7b. NO. OF REFS |
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| 10. DISTRIBUTION STATEMENT<br>Approved for public release; distribution unlimited. | |
| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY<br>U. S. Army Materiel Command<br>Washington, D. C. |

13. ABSTRACT

A study was made to determine the feasibility of using an airborne laser profilometer system to rapidly appraise selected unprepared landing sites. Evaluation of terrain roughness was made in terms of microrelief, slope, and obstructions. Laser profilometer data were collected at 12 test areas that provided variations in surface geometry, vegetation cover, and other natural and man-made features. The inherent characteristics of the laser profilometer system and the extraneous noise present in the laser profilometer output prevented a direct quantitative comparison of the laser profilometer output and reference profiles of the terrain. To overcome this difficulty, a procedure was developed for interpreting the laser profilometer output to obtain an interpreted terrain profile for comparison with reference profiles. A total of 17 specific terrain features at the 12 test areas were chosen for analysis of the capabilities of the laser profilometer system. Comparisons of the dimensions of the features as measured on the interpreted terrain profiles and reference profiles showed that the height of terrain features could be measured with a probable error of $\pm 4$ in. and a maximum error of approximately 12 in. The ability of the laser profilometer system to measure terrain slope was evaluated by comparing measurements of the change in elevation over a 328-ft interval as obtained on laser profilometer outputs and photogrammetric reference profiles. The laser profilometer system did not accurately measure terrain slope in direction (+ or -) or magnitude.

KEYWORDS: Field tests; Lasers; Microgeometry; Profilometers; Terrain; Unsurfaced runway performance and evaluation

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| 1. ORIGINATING ACTIVITY *(Corporate author)* U. S. Army Engineer Waterways Experiment Station, Vicksburg, Miss. | 2a. REPORT SECURITY CLASSIFICATION Unclassified<br>2b. GROUP |

3. REPORT TITLE

CHARACTERIZING VEGETATION FROM EXISTING SOURCE MATERIAL FOR PREDICTING MUNITION HEIGHT OF BURST IN INACCESSIBLE AREAS

4. DESCRIPTIVE NOTES *(Type of report and inclusive dates)*

Final report

5. AUTHOR(S) *(First name, middle initial, last name)*

Hollis H. Allen
John G. Collins

| 6. REPORT DATE | 7a. TOTAL NO. OF PAGES | 7b. NO. OF REFS |
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| b. PROJECT NO. | |
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10. DISTRIBUTION STATEMENT

Approved for public release; distribution unlimited.

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| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY U. S. Army Materiel Command, Washington, D. C. |

13. ABSTRACT

In this study a procedure for characterizing vegetation of inaccessible areas for input to munition height-of-burst models was developed. The procedure entails three steps: (a) statistical stratification, (b) vegetation sampling, and (c) vegetation data transformation. An area is stratified on the basis of average height, crown diameter, and spacing of plants in the upper two layers using the WES factor mapping process. For each unique combination of factors mapped, a 20-plant minimum sample is taken for each height layer. Sample data include average spacing of plants and the height and crown diameter of each plant. Data are obtained photogrammetrically when feasible; otherwise; available ground-truth data are substituted. Plants with known stem and branch geometries are then substituted for the sample plants.

KEYWORDS: Mathematical models; Munition effectiveness; Performance prediction; Vegetation; Vegetation structure

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| 1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Mississippi | 2a. REPORT SECURITY CLASSIFICATION Unclassified |
| | 2b. GROUP |

3. REPORT TITLE
ENVIRONMENTAL CHARACTERISTICS AT LINE SENSOR SITES, WOODBRIDGE AND FORT BELVOIR, VIRGINIA

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
Final report

5. AUTHOR(S) (First name, middle initial, last name)
Charles A. Miller

| 6. REPORT DATE | 7a. TOTAL NO. OF PAGES | 7b. NO. OF REFS |
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| b. PROJECT NO. | |
| c. Tasks A2R17C03581 and A2R17001081 | 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) AD A012 631 |
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10. DISTRIBUTION STATEMENT
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| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY |
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| | U. S. Army Mobility Equipment Research and Development Center Fort Belvoir, Virginia |

13. ABSTRACT

Basic environmental data were collected and recorded at the strain-sensitive cable sensor (SSCS) test site, Woodbridge, Virginia, and the Range 4 EPG site, Fort Belvoir, Virginia, to compare and correlate variations in SSCS output with changes in environmental characteristics at the sites. At the Woodbridge site, data were collected at points of known extremes in SSCS performance, whereas at the Range 4 EPG site a more general collection program was performed. The data collected at the Range 4 site were also used to determine suitable locations for nuclear moisture-density tube installations. Analysis of the data showed that at both sites subsurface conditions existed in which the applied load of a man walking would influence only the elastic region of the soil. Consequently, higher SSCS output should be found in areas of less rigid material and a lower output would result from a more rigid material. This prediction of sensor performance is limited, however, since the data were collected during a period of very dry weather, which affected the strength and deformation characteristics of the soil.

KEYWORDS: Environmental analysis; Field tests; Military bases; Pressure cells (Soils); [Fort Belvoir, Va.; Woodbridge, Va.]; Sensors

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U. S. Army Engineer Waterways Experiment Station
Vicksburg, Mississippi

**2a. REPORT SECURITY CLASSIFICATION**
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**2b. GROUP**

**3. REPORT TITLE**
MUNITION BURST PROBABILITY AS RELATED TO VEGETATION, FUZE, AND MUNITION TRAJECTORY CHARACTERISTICS

**4. DESCRIPTIVE NOTES (Type of report and inclusive dates)**
Final report

**5. AUTHOR(S) (First name, middle initial, last name)**
John G. Collins
Hollis H. Allen

| 6. REPORT DATE | 7a. TOTAL NO. OF PAGES | 7b. NO. OF REFS |
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**8a. CONTRACT OR GRANT NO.**

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**9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)**
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**11. SUPPLEMENTARY NOTES**

**12. SPONSORING MILITARY ACTIVITY**
U. S. Army Materiel Command, Program Manager for Selected Ammunition
Dover, N. J.

**13. ABSTRACT**
An analytical model for predicting munition burst probability in vegetation was developed. Vegetation characteristics incorporated in the model included branch coverage, branch orientation, and branch diameter; fuze diameter, munition height, munition entry angle, and munition terminal velocity were also accounted for. Using linear regression techniques the model was fitted to measured test data obtained in mixed hardwood, pine, and tropical rain forests for the M524, M533, and M557 impact fuzes. Results of the study indicated the following: (a) burst probability increases linearly with increases in branch coverage, (b) vegetation data were not always consistent with measured burst probability data, (c) detailed stem and branch data can be extrapolated from sample sites to nearby fuze test sites, (d) generalized vegetation data can be used successfully to predict munition burst height, (e) theoretical and controlled laboratory studies to define impact fuze-branch interaction should be continued, and (f) greater care and effort should be made in the data collection phase of all fuze tests conducted in the field.

KEYWORDS: Forests; Mathematical models; Munition effectiveness; Probability theory; Vegetation; Vegetation structure

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**1. ORIGINATING ACTIVITY (Corporate author)**
U. S. Army Engineer Waterways Experiment Station
Vicksburg, Mississippi

**2a. REPORT SECURITY CLASSIFICATION**
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**2b. GROUP**

**3. REPORT TITLE**
THE USE OF REMOTE SENSING TECHNIQUES FOR DETECTION AND IDENTIFICATION OF POLLUTANT DISCHARGES

**4. DESCRIPTIVE NOTES (Type of report and inclusive dates)**
Final report

**5. AUTHOR(S) (First name, middle initial, last name)**
Lewis E. Link, Jr.

| 6. REPORT DATE | 7a. TOTAL NO. OF PAGES | 7b. NO. OF REFS |
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**b. PROJECT NO.** 4A162121A891

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**9a. ORIGINATOR'S REPORT NUMBER(S)**
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**9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)**
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**10. DISTRIBUTION STATEMENT**
Approved for public release; distribution unlimited.

**11. SUPPLEMENTARY NOTES** Report was also submitted to Mississippi State University, State College, Miss., as thesis for degree of Master of Science in Civil Engineering

**12. SPONSORING MILITARY ACTIVITY**
Office, Chief of Engineers, U. S. Army
Washington, D. C.


**13. ABSTRACT** Simulation models are potentially excellent tools for evaluating the water quality conditions of a river basin. The effectiveness of these tools can only be realized, however, if all of the necessary data inputs to the model are obtainable in a practical manner. Among the necessary inputs to water quality simulation models are the location and type of pollutant discharges into the river basin. The acquisition of these data is formidable, especially if the only data collection procedure utilized is field sampling. The purpose of this study was to evaluate photographic remote sensing techniques for detecting and identifying pollutant discharges. A number of investigations have been conducted to examine the utility of remote sensing techniques for application to water quality problems. These studies have been largely qualitative, however, they have shown that photographic remote sensing techniques have considerable potential in this area. A more definitive evaluation of this potential awaits a quantitative evaluation scheme. This study consisted of (1) the development of a computerized remote sensing simulation model to provide a quantitative, systematic means to rapidly assess the capabilities of photographic remote sensing techniques for application to specific problems and (2) the use of the remote sensing simulation model to evaluate the utility of these techniques for the detection and identification of pollutant discharge. The remote sensing simulation model includes mathematical relations that describe atmospheric attenuation of electromagnetic (EM) radiation, reflection of EM radiation from materials, and the interaction of EM radiation with photographic remote sensing systems. The model provides a means of determining if photographic remote sensors are applicable to a specific problem and, if so, which sensors have the most potential. Spectral reflectance curves for pollutants and water bodies were obtained from the literature and used as inputs to the remote sensing simulation model. The resulting predictions were used to evaluate photographic remote sensing techniques for detection and identification of pollutant discharges. The results of this study indicated that selected photographic remote sensing techniques were theoretically capable of detecting pollutant discharges for each of the pollutant types used in this study.



KEYWORDS: Computerized simulation, Mathematical models; Photography; Pollutants; Remote sensing; Water pollution; Water quality


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| 1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Miss. | 2a. REPORT SECURITY CLASSIFICATION Unclassified |
| | 2b. GROUP |

3. REPORT TITLE

GENERATION AND PROPAGATION OF MICROSEISMIC SIGNALS FROM FOOTSTEPS

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
Final report


5. AUTHOR(S) (First name, middle initial, last name)
Jerry R. Lundien
Bob O. Benn


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| 6. REPORT DATE September 1973 | 7a. TOTAL NO. OF PAGES 90 | 7b. NO. OF REFS 7 |

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10. DISTRIBUTION STATEMENT

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| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY Project Manager, Remotely Monitored Battlefield Surveillance System U. S. Army Materiel Command, Fort Monmouth, New Jersey |

13. ABSTRACT


A study was conducted to investigate the generation and propagation of microseismic signals from man-walking targets. To illustrate the relation between terrain parameters and Rayleigh wave generation and propagation, the problem was divided into four parts, which were then studied graphically. These parts were: (a) the target-ground interaction, (b) energy coupling to the substrate, (c) Rayleigh wave propagation from the source, and (d) transmission of Rayleigh waves over surface macrogeometry features. Parameters that are included in the terrain model are: (a) surface rigidity in terms of nonlinear surface spring constants and (b) subsurface rigidity in terms of seismic properties (wave velocities and bulk density) and layer thickness. The terrain combinations include a wide variation in site conditions and have realism in terms of environments found in nature. Sample problems are included to demonstrate the signal construction techniques and are analyzed to show the effect of the various terrain parameters on the generation and propagation of the Rayleigh waves.



KEYWORDS: Microseismic waves; Seismic investigations; Terrain factors; Terrain models (Analytical); Wave propagation


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| 1. ORIGINATING ACTIVITY (Corporate author)<br>U. S. Army Engineer Waterways Experiment Station<br>Vicksburg, Mississippi | 2a. REPORT SECURITY CLASSIFICATION<br>Unclassified<br>2b. GROUP |

3. REPORT TITLE

REPORT OF THIRD PROGRAM REVIEW OF SEISMIC SENSOR SYSTEMS INVESTIGATION

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

5. AUTHOR(S) (First name, middle initial, last name)

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| 6. REPORT DATE<br>November 1973 | 7a. TOTAL NO. OF PAGES<br>254 | 7b. NO. OF REFS |

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| 8a. CONTRACT OR GRANT NO.<br>b. PROJECT NO. 1T162112A131 | 9a. ORIGINATOR'S REPORT NUMBER(S)<br>Miscellaneous Paper - Unnumbered |
| c.<br>d. | 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)<br>AD A017 728 |

10. DISTRIBUTION STATEMENT

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| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY<br>Directorate of Research, Development and Engineering<br>U. S. Army Materiel Command |

13. ABSTRACT


Presentations at the meeting held at the Army Research Office, Arlington, Va. on 15 February 1973 included: "Program Background, Related Programs at WES" (Benn); "Evaluation of WES SID Performance Prediction (Man-Walking Targets) in West Germany" (Link); "Terrain Considerations in SID Testing" (West); "Terrain Constraints on Air-Delivered SID's Sensor Implantation" (Rohani); "The Use of Predicted Vehicle Signatures for SID Design and Deployment" (Lundien); "Vehicle Signature Acquisition Program" (Parks); "Sensor Logic Design Concepts" (Keehan); "Seismic Sensors in Cold Regions - Program Review" (Stevens and Wolfe); "Interrelation of WES and REMBASS Programs" (Bernstein); "Worldwide Utilization of UGS" (Hunter); "Rapid Design of Sensor Fields" (Benn).



KEYWORDS: Meetings; Seismic investigations; Seismic sensors; State-of-the-art studies


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| 1. ORIGINATING ACTIVITY (Corporate author)<br>U. S. Army Engineer Waterways Experiment Station<br>Vicksburg, Miss. | 2a. REPORT SECURITY CLASSIFICATION<br>Unclassified<br>2b. GROUP |

3. REPORT TITLE

THE EFFECT OF MILITARY TRANSPORTATION ACTIVITIES ON THE ENVIRONMENT

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
Final report

5. AUTHOR(S) (First name, middle initial, last name)
Andrew J. Green
Donald D. Randolph
Adam A. Rula

| 6. REPORT DATE | 7a. TOTAL NO. OF PAGES | 7b. NO. OF REFS |
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| December 1973 | 73 | 22 |

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| 8a. CONTRACT OR GRANT NO.<br>CERL-73-9<br>b. PROJECT NO.<br>Project/Task/Work Unit No. 891-05-01-001,<br>c. "Procedures for Evaluating Environmental Impacts of Army Military Programs"<br>d. | 9a. ORIGINATOR'S REPORT NUMBER(S)<br>Miscellaneous Paper M-73-15<br>9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)<br>AD A032 971 |

10. DISTRIBUTION STATEMENT

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| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY<br>U. S. Army Construction Engineering Research Laboratory<br>Champaign, Illinois |

13. ABSTRACT

The study reported herein was undertaken to evaluate the impact of military transportation activities upon related environmental attributes. The military activities were related to their impact on these attributes by means of a matrix. This matrix used a scale to identify the magnitude and probability of the impact. Additionally, known mitigation and abatement practices that can be used to minimize adverse environmental impacts were identified and briefly described. The principal conclusion was that this technique provided a first approximation for assessing the effect of military transportation on the environment. It is recommended that funding be provided to: (a) exploit existing data to generate quantitative relations to be used in developing environmental impact statements and (b) finance research in those areas for which the need to quantify exists and the lack of data has been acknowledged.

KEYWORDS: Environmental effects; Military operations; Transportation

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## DOCUMENT CONTROL DATA - R & D

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|---|---|
| 1. ORIGINATING ACTIVITY (Corporate author)<br>U. S. Army Engineer Waterways Experiment Station<br>Vicksburg, Mississippi | 2a. REPORT SECURITY CLASSIFICATION<br>Unclassified<br>2b. GROUP |

3. REPORT TITLE
THEORETICAL STUDY OF IMPACT AND PENETRATION OF A REMOTELY EMPLACED ANTITANK MINE PROJECTILE INTO EARTH MATERIALS

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
Final report

5. AUTHOR(S) (First name, middle initial, last name)
Behzad Rohani

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| 6. REPORT DATE<br>June 1973 | 7a. TOTAL NO. OF PAGES<br>34 | 7b. NO. OF REFS<br>10 |

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| 8a. CONTRACT OR GRANT NO.<br>b. PROJECT NO. 1X564619D01618<br>c.<br>d. | 9a. ORIGINATOR'S REPORT NUMBER(S)<br>Miscellaneous Paper S-73-58<br>9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)<br>AD 911 692L |

10. DISTRIBUTION STATEMENT
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| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY<br>U. S. Army, Picatinny Arsenal<br>Dover, New Jersey |

13. ABSTRACT

This report presents the results of a theoretical study of the penetration and impact of an air-delivered antitank mine projectile into earth materials within an impact velocity range of 100-400 fps. The earth materials simulated as target materials ranged from soft clay soils to hard frozen ground and low-strength rock. The theoretical results are presented in terms of impact velocity-maximum depth of penetration relations and impact velocity-peak dynamic stress relations for a variety of target materials within the specified impact velocity range.

KEYWORDS: Mines (Ordnance); Projectiles; Soil penetration; Soil penetration tests

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1. ORIGINATING ACTIVITY (Corporate author)
U. S. Army Engineer Waterways Experiment Station
Vicksburg, Mississippi

2a. REPORT SECURITY CLASSIFICATION
Unclassified

2b. GROUP

3. REPORT TITLE
TERRAIN ANALYSIS FOR THE ARMORED RECONNAISSANCE SCOUT VEHICLE TEST PROGRAM

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

5. AUTHOR(S) (First name, middle initial, last name)
Donald D. Randolph
Claude A. Blackmon

6. REPORT DATE
March 1974

7a. TOTAL NO. OF PAGES
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9a. ORIGINATOR'S REPORT NUMBER(S)
Miscellaneous Paper - Unnumbered

9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)
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10. DISTRIBUTION STATEMENT
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11. SUPPLEMENTARY NOTES
Conducted by WES and USATAC. Directed by U. S. Army Materiel Systems Analysis Agency, Aberdeen Proving Ground, Maryland

12. SPONSORING MILITARY ACTIVITY
Armored Reconnaissance Scout Vehicle Project Manager
U. S. Army Tank-Automotive Command
Warren, Michigan

13. ABSTRACT
Two study areas (FK1 and FK2), totaling approximately 11 sq miles were selected at Fort Knox, Kentucky, for comparison with a previously mapped 60-sq-mi sample of terrain in West Germany (WGT) and as potential areas for field tests with the prototype Armored Reconnaissance Scout Vehicles (ARSV's) and comparison vehicles. Areal and linear terrain data from 119 sites, aerial photographs, and other pertinent information were used to prepare the Fort Knox terrain factor complex maps. These areal maps describe the terrain characteristics that affect vehicle performance, i.e. soil type, soil strength, topographic slope, obstacles, vegetation, surface roughness, and visibility. The linear terrain factor complex maps describe the terrain characteristics that determine "go or no-go" vehicle performance, i.e. linear feature geometry, water depth, and water velocity. The Fort Knox study areas and the West German transect were compared on the basis of general descriptions (land physical characteristics, land use, etc.), areal and linear occupancy and occurrence of terrain units and terrain mobility factors, and parameters (i.e. vehicle speed and performance diagnostics) reflecting the combined effects of the terrain upon the mobility performance of the M114A1E1 armored command and reconnaissance carrier and the M151A2, 1/4-ton truck, as predicted by the AMC-71 mobility model.

KEYWORDS: Military bases; Mobility; Reconnaissance vehicles; Temperate regions; Terrain analogs; Terrain analysis; Terrain factor maps; Trucks; [Ft. Knox, Kentucky]

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| 1. ORIGINATING ACTIVITY (Corporate author)<br>U. S. Army Engineer Waterways Experiment Station<br>Vicksburg, Miss. | 2a. REPORT SECURITY CLASSIFICATION<br>Unclassified<br>2b. GROUP |

3. REPORT TITLE
REMOTE-SENSING PRACTICE AND POTENTIAL

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
Final report

5. AUTHOR(S) (First name, middle initial, last name)
Albert N. Williamson
William K. Dornbusch
Warren E. Grabau

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| 6. REPORT DATE<br>May 1974 | 7a. TOTAL NO. OF PAGES<br>93 | 7b. NO. OF REFS |
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| 11. SUPPLEMENTARY NOTES<br>Prepared for Seminar on Regional Resources Management, Univ. of Florida, Jan 1974. | 12. SPONSORING MILITARY ACTIVITY |

13. ABSTRACT
Successful use of remote sensors requires considerably more than just taking some imagery or flying an area. Six essential processes that must be accomplished if use of a remote-sensing system is to result in useful information are defined herein as problem specification, ground control data acquisition, remote-sensor information acquisition, data manipulation, information extraction, and information presentation. Identification of these processes is the result of much experience at WES in remote-sensing techniques. Several fairly common and not so common sensor types are introduced, and some devices and information extraction and presentation techniques found to be useful in remote-sensing projects are described. An overview of the current state-of-the-art of remote sensing is presented and some of the current remote-sensing capabilities of WES are introduced.

KEYWORDS: Information systems; Remote sensing; Sensors; State-of-the-art studies

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| | 2b. GROUP |

3. REPORT TITLE
REPORT OF SYMPOSIUM ON THE DESIGN, TESTING, AND DEPLOYMENT OF UNATTENDED GROUND SENSORS; U. S. ARMY ENGINEER WATERWAYS EXPERIMENT STATION, VICKSBURG, MISSISSIPPI, 11-12 SEPTEMBER 1973

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

5. AUTHOR(S) (First name, middle initial, last name)

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| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY Project Manager's Office, Remotely Monitored Battle Area Sensor System, Army Materiel Command |

13. ABSTRACT

Discussions at the symposium were concerned with the seismic sensor logic for classifying targets and locating their positions. Priority was given to the current WES research efforts but other pertinent presentations were made. Subjects included "User Requirements for Classifying Sensors; Regional Design Base for Classifying Sensor; Vehicle Dynamics in Seismic Classified Design; Modeling Seismic Signatures from Vehicles; Multisignature Vehicle Discrimination; Measuring Seismic and Acoustic Signatures; Site Condition Documentation for Seismic and Acoustic Measurements; Discussion on Classifiers; Additional Capability for Sensor Processors; Detection Capability of Strain Sensitive Cable Sensors; Preliminary Results of Phase Measurements (Seismic) for Target Position Location; Practical Considerations in Estimating Target Time of Arrival; Terrain Description and Mapping for Sensor Deployment; Projectile Penetration Studies of Terminal Delivery Vehicle T-98WA in Frozen and Unfrozen Soils."

KEYWORDS: Meetings; Seismic investigations; Seismic sensors; State-of-the-art studies

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| 1. ORIGINATING ACTIVITY (Corporate author)<br>U. S. Army Engineer Waterways Experiment Station<br>Vicksburg, Miss. | 2a. REPORT SECURITY CLASSIFICATION<br>Unclassified<br>2b. GROUP |

3. REPORT TITLE

EXPERIMENTAL STUDY OF TRIPLINE DEPLOYMENTS IN SELECTED ENVIRONMENTS AT JEFFERSON PROVING GROUND, INDIANA

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
Final report

5. AUTHOR(S) (First name, middle initial, last name)

Harold W. West
Victor E. LaGarde

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| b. PROJECT NO. | Miscellaneous Paper M-74-4 |
| c. | 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) |
| d. | AD 920 453L |

10. DISTRIBUTION STATEMENT

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| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY<br>U. S. Army Picatinny Arsenal<br>Dover, New Jersey |

13. ABSTRACT

An experimental study of the deployment of air-delivered antipersonnel mine (ADAM) triplines in various test environments was conducted at Jefferson Proving Ground, Indiana. The ADAM contains seven line-laying devices (projectiles), each consisting of a line-loaded spool attached to a spring. Upon release, the springs carry the wire spools away from the mine body, laying the tripline in the process. Tests were conducted from 9 Jul to 7 Sep 1973 to determine the deployment characteristics and effectiveness of the triplines in six test environments: short grass, tall grass, brush, bare earth, water, and forest. Tripline deployment data were obtained from three-dimensional survey measurements taken of the mine body and at selected points along each (deployed) tripline. Only the experimental data on the tripline deployment and effectiveness tests are presented herein. The data will be analyzed by the sponsor. In support of the ADAM tripline tests, quantitative terrain data were collected, including vegetation description and identification, stem density (i.e. stems per unit area), and plant three-dimensional-geometry data on the predominant species in three vegetation areas (short grass, tall grass, and brush), and soil strength (in terms of cone index) and soil type data in a bare-earth area. General descriptions were also obtained for water and forested areas.

KEYWORDS: Environments; Field tests; Military bases; Mines (Ordnance); Terrain factors; [Jefferson Proving Ground, Indiana]

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| 1. REPORT NUMBER<br>Miscellaneous Paper M-74-8 | 2. GOVT ACCESSION NO.<br>AD A001 520 | 3. RECIPIENT'S CATALOG NUMBER |
| 4. TITLE (and Subtitle)<br>MAPPING OF SELECTED ARSV TEST COURSES AT FORT KNOX, KENTUCKY, AND COMPARISON WITH OTHER SELECTED TERRAINS | | 5. TYPE OF REPORT & PERIOD COVERED<br>Final Report<br>6. PERFORMING ORG. REPORT NUMBER |
| 7. AUTHOR(s)<br>Donald D. Randolph | | 8. CONTRACT OR GRANT NUMBER(s) |
| 9. PERFORMING ORGANIZATION NAME AND ADDRESS<br>U. S. Army Engineer Waterways Experiment Station<br>Mobility and Environmental Systems Laboratory<br>P. O. Box 631, Vicksburg, Miss. 39180 | | 10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS |
| 11. CONTROLLING OFFICE NAME AND ADDRESS<br>U. S. Army Materiel Systems Analysis Agency<br>Aberdeen Proving Ground, Maryland 21005 | | 12. REPORT DATE<br>October 1974<br>13. NUMBER OF PAGES<br>26 |
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18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

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| Military bases | Terrain analogs | [W. Germany] |
| Military vehicles | Terrain analysis | |
| Mobility | Terrain factor maps | |
| Temperate regions | [Fort Knox, Ky.] | |

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Two test courses (FKDC and FKNC) at Fort Knox, Kentucky, totaling approximately 37.4 miles of roads and trails that had been used for conducting vehicle tests with Armored Reconnaissance Scout Vehicles (ARSV's) and comparable vehicles, were mapped by techniques developed by the U. S. Army Engineer Waterways Experiment Station. The factors mapped were soil type, soil strength, topographic slope, obstacles, surface roughness, and visibility. Standing vegetation was not present on any of the trails. The study also included
(Continued)

20. ABSTRACT (Continued).

a limited comparison of the two test courses (FKDC and FKNC) with other Fort Knox terrains (FK1, FK2) and West Germany terrain (WGT). FK1, FK2, and WGT were mapped in previous studies on the basis of the single factors used to describe these test courses, i. e. soil strength, slope, surface roughness, obstacle magnitude, and visibility. It was concluded that the surface strengths of FKDC and FKNC are greater than those of FK1, FK2, and WGT. The slopes in FKDC and FKNC are similar to those in FK2 and WGT. The surface roughness and obstacle magnitude are greater in FKNC than in any of the other areas. The obstacle vertical magnitude factor classes are greater for FKNC than for FKDC or WGT. The visibility is somewhat similar and quite good in all the areas considered. Based on the five factors considered (soil strength, slope, surface roughness, obstacle vertical magnitude, and visibility), FKDC is more similar to WGT than is FKNC, and FKNC is more similar to FK2 than to FK1, FKDC, and WGT. It is recommended that the AMC-71 Mobility Model be used to compare speed performance of the ARSV vehicles and comparison vehicles over the test courses.

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| 1. REPORT NUMBER<br>Miscellaneous Paper M-75-1 | 2. GOVT ACCESSION NO.<br>AD A005 147 | 3. RECIPIENT'S CATALOG NUMBER |
| 4. TITLE (and Subtitle)<br>A POSSIBLE DECISION STRUCTURE FOR ENVIRONMENTAL MANAGEMENT | | 5. TYPE OF REPORT & PERIOD COVERED<br>Final report<br>6. PERFORMING ORG. REPORT NUMBER |
| 7. AUTHOR(s)<br>Warren E. Grabau<br>Bob O. Benn | | 8. CONTRACT OR GRANT NUMBER(s) |
| 9. PERFORMING ORGANIZATION NAME AND ADDRESS<br>U. S. Army Engineer Waterways Experiment Station<br>Mobility and Environmental Systems Laboratory<br>P. O. Box 631, Vicksburg, Miss. 39180 | | 10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS<br>Project 4A162121A896<br>Task 01, Work Unit 003 |
| 11. CONTROLLING OFFICE NAME AND ADDRESS<br>Office, Chief of Engineers, U. S. Army<br>Washington, D. C. 20314 | | 12. REPORT DATE<br>January 1975<br>13. NUMBER OF PAGES<br>23 |
| 14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office) | | 15. SECURITY CLASS. (of this report)<br>Unclassified<br>15a. DECLASSIFICATION/DOWNGRADING SCHEDULE |
| 16. DISTRIBUTION STATEMENT (of this Report)<br>Approved for public release; distribution unlimited. | | |
| 17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report) | | |
| 18. SUPPLEMENTARY NOTES | | |
| 19. KEY WORDS (Continue on reverse side if necessary and identify by block number)<br>Environmental analysis<br>Environmental models (Analytical)<br>Mathematical models<br>Military bases<br>Military operations | | |

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)


A flow diagram is presented that outlines the logic and data requirements for making decisions in the environmental management of a military reservation. Each block of the diagram is explained. Generally speaking, an activity to be conducted on the reservation can be carried through the diagram from the decision to conduct it to a choice of decisions: cancel, conduct in different region, conduct at different time, conduct alternative operation, or plan remedial action. Along the way, data requirements are


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20. ABSTRACT (continued).

defined, reference sources are suggested, and damage to the environment and consequences of remedial action are predicted. Existing mathematical models are used when available, and development of additional mathematical models is recommended where appropriate.

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| REPORT DOCUMENTATION PAGE | | READ INSTRUCTIONS BEFORE COMPLETING FORM |
|---|---|---|
| 1. REPORT NUMBER: Miscellaneous Paper M-75-2 | 2. GOVT ACCESSION NO.: AD A005 148 | 3. RECIPIENT'S CATALOG NUMBER |
| 4. TITLE (and Subtitle): A GUIDE FOR COLLECTING SEISMIC, ACOUSTIC, AND MAGNETIC DATA FOR MULTIPLE USES | | 5. TYPE OF REPORT & PERIOD COVERED: Final report |
| | | 6. PERFORMING ORG. REPORT NUMBER |
| 7. AUTHOR(s): Bob O. Benn and Perry A. Smith | | 8. CONTRACT OR GRANT NUMBER(s) |
| 9. PERFORMING ORGANIZATION NAME AND ADDRESS: U. S. Army Engineer Waterways Experiment Station, Mobility and Environmental Systems Laboratory, WESFV, P. O. Box 631, Vicksburg, Miss. 39180 | | 10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS |
| 11. CONTROLLING OFFICE NAME AND ADDRESS: U. S. Army Materiel Command, 5001 Eisenhower Avenue, Alexandria, Virginia 22304 | | 12. REPORT DATE: January 1975 |
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17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Acoustics
Data acquisition
Electromagnetic radiation
Microseismic waves
Seismic investigations
Vehicle signature

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Three self-contained documents (Parts 2, 3, and 4) set forth guidelines for the design and implementation of seismic, acoustic, and magnetic signature data collection programs, respectively, such that the data obtained will have general applicability. The information is intended to be a broad reference for planners of such programs. In each part, methods are given for documenting the characteristics of the targets (men, vehicles, etc.) and test sites, instrumentation requirements are set forth, and test procedures are discussed.
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20. ABSTRACT (Continued).

Appendix A explains the generation, propagation, and sensing of microseismic energy.

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| 1. REPORT NUMBER<br>DNA PR 0008 | 2. GOVT ACCESSION NO.<br>AD A011 493 | 3. RECIPIENT'S CATALOG NUMBER |
| 4. TITLE (and Subtitle)<br>PROJECT ESSEX I<br>Phase 1, Mobility Experiments | | 5. TYPE OF REPORT & PERIOD COVERED<br>Final report covering period from August-October 1973<br>6. PERFORMING ORG. REPORT NUMBER<br>Miscellaneous Paper M-75-3 |
| 7. AUTHOR(s)<br>Charles E. Green | | 8. CONTRACT OR GRANT NUMBER(s) |
| 9. PERFORMING ORGANIZATION NAME AND ADDRESS<br>U. S. Army Engineer Waterways Experiment Station<br>Mobility and Environmental Systems Laboratory<br>P. O. Box 631, Vicksburg, Mississippi 39180 | | 10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS<br>DNA Subtask L19EAXSX301, Work Unit 002; and DA Project 4A162118A880, Task 04, Work Unit 002 |
| 11. CONTROLLING OFFICE NAME AND ADDRESS<br>Defense Nuclear Agency, Washington, D. C. 20305; and Office, Chief of Engineers, U. S. Army, Washington, D. C. 20314 | | 12. REPORT DATE<br>April 1975<br>13. NUMBER OF PAGES<br>92 |
| 14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)<br>U. S. Army Engineer Waterways Experiment Station<br>Explosive Excavation Research Laboratory<br>P. O. Box 631, Vicksburg, Mississippi 39180 | | 15. SECURITY CLASS. (of this report)<br>Unclassified<br>15a. DECLASSIFICATION/DOWNGRADING SCHEDULE |

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18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

| | | |
|---|---|---|
| Crater ejecta | Military vehicles | Terrain |
| Craters | Mobility | [ESSEX I (Program)] |
| Explosion effects | Obstacles | [Fort Polk, La.] |
| Military bases | Performance predictions | |

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Project ESSEX I, Phase 1, consisted of the detonation of three 11,249-kilogram (12.4-ton) charges and one 8,981-kilogram (9.9-ton) charge of gelled nitromethane at different depths of burial and stemming conditions at the Peason Ridge Artillery Range of Fort Polk, Louisiana, at intermittent periods from 23 August to 31 October 1973. Mobility experiments were conducted to determine the degree to which the craters and their associated ejecta fields constitute a physical barrier to the movement of military vehicles. Four terrain

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20. ABSTRACT (Continued)

units in each crater and ejecta area were delineated as significant to ground mobility and described in terms of soil strength, soil moisture content, surface configuration, ejecta depth, and areal extent. The test vehicles (i.e. the M60 tank, the M113A1 armored personnel carrier, and the M715 cargo truck) could operate with ease in all the terrains except the crater walls (Terrain Unit 4) and the crater floors (Terrain Unit 5). The crater walls were impassable for all the test vehicles because of steep slopes, and the crater floors of all the craters were impassable for the M60 and M715 because of soft soil conditions. The M113A1 could operate on the crater floors of all the craters except the 12-MS. The engineering effort (time required by a D8 bulldozer) to make the craters passable for the test vehicles was 2.33 hours on the 12-MS crater, 3 hours on the 12-MPS crater, 2.17 hours on the 6-MS crater, and 3 hours (estimated) on the 6-MU crater. Degradation of vehicle performance in terms of drawbar-pull coefficient and speed increased for all three test vehicles in each terrain unit from the original surface to GZ. On the basis of degraded area per charge yield, the 6-MU crater was the most effective for all three test vehicles. The 12-MPS crater was the least effective for the M113A1, and the 12-MS crater was the least effective for the M60 and M715. Vehicle performance in the terrain units was predicted using the U. S. Army Materiel Command Ground Mobility Model (AMC-71) for predicting off-road vehicle performance, and measured and predicted values for four performance parameters (drawbar pull, go-no go, motion resistance, and speed) were compared. The accuracy of the predictions was acceptable for all performance parameters except vehicle speed in the cratered areas.

## REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

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|---|---|
| 1. REPORT NUMBER | Miscellaneous Paper M-75-4 |
| 2. GOVT ACCESSION NO. | AD B005 325L |
| 3. RECIPIENT'S CATALOG NUMBER | |
| 4. TITLE (and Subtitle) | TERRAIN DESCRIPTION, VEHICLE MOBILITY, AND COVER AND CONCEALMENT CHARACTERISTICS FOR THE BUSHMASTER MIDDLE EAST AND EUROPE SCENARIOS: A QUALITATIVE ASSESSMENT |
| 5. TYPE OF REPORT & PERIOD COVERED | Final report |
| 6. PERFORMING ORG. REPORT NUMBER | |
| 7. AUTHOR(s) | Harold W. West<br>Barton G. Schreiner |
| 8. CONTRACT OR GRANT NUMBER(s) | |
| 9. PERFORMING ORGANIZATION NAME AND ADDRESS | U. S. Army Engineer Waterways Experiment Station<br>Mobility and Environmental Systems Laboratory<br>P. O. Box 631, Vicksburg, Miss. 39180 |
| 10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS | |
| 11. CONTROLLING OFFICE NAME AND ADDRESS | Bushmaster Task Force<br>Headquarters, U. S. Army Training and Doctrine Command, Fort Monroe, Va. 23651 |
| 12. REPORT DATE | May 1975 |
| 13. NUMBER OF PAGES | 31 |
| 14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office) | |
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18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

| | | |
|---|---|---|
| Computerized simulation | Mobility | [Bushmaster (Weapons system)] |
| Concealment | Performance predictions | [Middle East] |
| Desert regions | Temperate regions | [West Germany] |
| Military operations | Terrain analysis | |
| Military vehicles | War games | |

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

A study was performed to provide terrain description, vehicle mobility, and cover and concealment characteristics on two 6- by 7-km areas; one in the Middle East and the other in West Germany. These data were then to be used as input to two war-game computer simulation models (the Bonder Individual Unit Action and Carmonette Models) in the overall program to perform a cost and operational analysis on the use of Bushmaster versus alternative weapon systems.
(Continued)

20. ABSTRACT (Continued)

Terrain data in terms of soil strength and ground surface roughness and predictions of vehicle speeds for six vehicles are provided. Cover and concealment estimates are also provided for a 300-cm-tall vertical target.

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| REPORT DOCUMENTATION PAGE | | READ INSTRUCTIONS BEFORE COMPLETING FORM |
|---|---|---|
| 1. REPORT NUMBER<br>Miscellaneous Paper M-75-6 | 2. GOVT ACCESSION NO.<br>AD B005 510L | 3. RECIPIENT'S CATALOG NUMBER |
| 4. TITLE (and Subtitle)<br>AN EXPERIMENT IN FIXED-INSTALLATION CAMOUFLAGE, AIRCRAFT SHELTER COMPLEX AT EGLIN AIR FORCE BASE, FLORIDA | | 5. TYPE OF REPORT & PERIOD COVERED<br>Final report<br>6. PERFORMING ORG. REPORT NUMBER |
| 7. AUTHOR(s)<br>Thomas L. Engdahl, William N. Rushing | | 8. CONTRACT OR GRANT NUMBER(s) |
| 9. PERFORMING ORGANIZATION NAME AND ADDRESS<br>U. S. Army Engineer Waterways Experiment Station<br>Mobility and Environmental Systems Laboratory<br>P. O. Box 631, Vicksburg, Miss. 39180 | | 10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS<br>USAF Project No. 1154PY02<br>DA Project No. 4A162121A859 |
| 11. CONTROLLING OFFICE NAME AND ADDRESS<br>Headquarters, Air Force Systems Command<br>U. S. Air Force, Washington, D. C. 20330<br>and<br>Office, Chief of Engineers, U. S. Army<br>Washington, D. C. 20314 | | 12. REPORT DATE<br>May 1975<br>13. NUMBER OF PAGES<br>84 |
| 14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office) | | 15. SECURITY CLASS. (of this report)<br>Unclassified<br>15a. DECLASSIFICATION/DOWNGRADING SCHEDULE |

16. DISTRIBUTION STATEMENT (of this Report)

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17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Camouflage
Military bases
Protective structures
[Eglin Air Force Base]

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Procedures used by the Waterways Experiment Station (WES) in developing and implementing a camouflage plan for 12 aircraft shelters at Eglin Air Force Base, Florida, are described in this report. The camouflage had to be effective against attack aircraft weaponry, particularly against the pilot's visual recognition and contrast-seeking sensing devices. The camouflage had to be spectrally and spatially compatible with the terrain for all times of the day and for all

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20. ABSTRACT (Continued).

seasons. Also, the camouflage had to be effected cheaply and, once established, had to require little maintenance. Because longevity of the camouflage was of primary concern, extensive use of live vegetation and pattern painting was deemed appropriate. Spectral reflectance data, aerial photography, and scale models were used in developing the camouflage plan, in which the following six factors that aid in identifying an object were considered: position, shape, shadow, texture, color, and movement. Aerial weaponry tests were conducted by the U. S. Air Force before all phases of the camouflage plan were completed, i.e., live vegetation had not begun to grow and the nonearthen portions of the shelters had not been painted. Even with only partial concealment achieved, the visible range of the shelters was decreased considerably when compared with that of aircraft shelters used by the North Atlantic Treaty Organization nations. With time, the natural vegetation will further blend the shelters into the surrounding environment, and additional aerial weaponry tests should be conducted to determine the full effectiveness of the camouflage. Appendix A is a detailed test plan developed by the U. S. Army Mobility Equipment Research and Development Center (MERDC), which describes concealment techniques that could be implemented with relative speed (i.e., live vegetation need not be used) and would be effective against sensing devices using the visible, the near- and far-infrared, and radar regions of the electromagnetic spectrum. Much of the MERDC plan was not used directly because of the high initial cost and excessive maintenance costs. However, it did provide useful insight into how the shelters could be camouflaged.

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| REPORT DOCUMENTATION PAGE | | READ INSTRUCTIONS BEFORE COMPLETING FORM |
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| 1. REPORT NUMBER<br>Miscellaneous Paper M-75-9 | 2. GOVT ACCESSION NO.<br>AD B014 780L | 3. RECIPIENT'S CATALOG NUMBER |
| 4. TITLE (and Subtitle)<br>TERRAIN CHARACTERISTICS DATA ACQUISITION STUDY AT FORT BRAGG, NORTH CAROLINA | | 5. TYPE OF REPORT & PERIOD COVERED<br>Final report |
| | | 6. PERFORMING ORG. REPORT NUMBER |
| 7. AUTHOR(s)<br>Thomas L. Engdahl | | 8. CONTRACT OR GRANT NUMBER(s) |
| 9. PERFORMING ORGANIZATION NAME AND ADDRESS<br>U. S. Army Engineer Waterways Experiment Station<br>Mobility and Environmental Systems Laboratory<br>P. O. Box 631, Vicksburg, Mississippi 39180 | | 10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS |
| 11. CONTROLLING OFFICE NAME AND ADDRESS<br>U. S. Army Materiel Command<br>Remotely Monitored Battlefield Sensor System<br>Fort Monmouth, New Jersey 07703 | | 12. REPORT DATE<br>September 1975 |
| | | 13. NUMBER OF PAGES<br>44 |
| 14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office) | | 15. SECURITY CLASS. (of this report)<br>Unclassified |
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18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Environmental factors
Military bases
Seismic sensors
Temperate regions
Terrain analysis
[Fort Bragg, N. C.]

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The U. S. Army Engineer Waterways Experiment Station (WES) collected both surface and subsurface environmental data at selected sites at Fort Bragg, North Carolina, during May and October 1974 to examine the variation in the data between periods of testing various sensors and sensor systems conducted by the Remotely Monitored Battlefield Sensor System (REMBASS), U. S. Army Materiel Command. The environmental characterization program was separated into three

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20. ABSTRACT (Continued)

tasks. The first two tasks (conducted in May and October 1974, respectively) consisted of complete characterizations (i.e. both surface and subsurface terrain sampling of the REMBASS test area and are discussed herein. If the variations in the environmental data between these two test periods were excessive, a third characterization program would be conducted upon termination of the REMBASS service testing program. The surface environmental factors measured for the first two tasks were moisture content, soil strength (cone index and plate-load relations), and surface geometry profile . The subsurface measurements included the thickness of each refraction layer, compression wave velocity, wet density, soil moisture versus depth, and cone index versus depth. The data collected in May and October 1974 were compared with data collected during a two-phase program conducted by WES during 1972 on sites within the same general area. Variations showed that the surface properties changes significantly within a short period (i.e. from May to October 1974), while subsurface properties remained relatively stable. As the time between testing periods increased, greater variations in the subsurface environmental factors became evident (i.e. comparison of the subsurface factors from 1972 to 1974). The degree of change of these factors depends on meteorological conditions and the stress levels imposed between testing periods. Therefore, it is recommended that all surface and subsurface environmental factors be collected if the REMBASS service tests are concluded after January 1975. Also, environmental data should be collected if new studies (e.g. new test programs) are initiated on the test sites, so that an adequate baseline can be established.

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| REPORT DOCUMENTATION PAGE | | READ INSTRUCTIONS BEFORE COMPLETING FORM |
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| 1. REPORT NUMBER<br>Miscellaneous Paper M-75-10 | 2. GOVT ACCESSION NO.<br>AD A018 346 | 3. RECIPIENT'S CATALOG NUMBER |
| 4. TITLE (and Subtitle)<br>RATIONALE AND PLAN FOR FIELD DATA ACQUISITION REQUIRED FOR THE RATIONAL DESIGN AND EVALUATION OF SEISMIC AND ACOUSTIC CLASSIFYING SENSORS | | 5. TYPE OF REPORT & PERIOD COVERED<br>Final report |
| | | 6. PERFORMING ORG. REPORT NUMBER |
| 7. AUTHOR(s)<br>Bob O. Benn | | 8. CONTRACT OR GRANT NUMBER(s) |
| 9. PERFORMING ORGANIZATION NAME AND ADDRESS<br>U. S. Army Engineer Waterways Experiment Station<br>Mobility and Environmental Systems Laboratory<br>P. O. Box 631, Vicksburg, Miss. 39180 | | 10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS<br>Project 1X764723DL73 |
| 11. CONTROLLING OFFICE NAME AND ADDRESS<br>Project Manager, Remotely Monitored Battlefield Sensor System, AMC<br>Fort Monmouth, New Jersey 07703 | | 12. REPORT DATE<br>November 1975 |
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18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Acoustics
Data acquisition
Remote sensing
Seismic sensors
Sensors
Vehicle signature

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

A major objective of the Project Manager, Remotely Monitored Battlefield Surveillance System (REMBASS), is the development of sensor systems capable of classifying targets. Existing classifier design procedures rely heavily on statistical techniques, such as multiple correlation analysis, which have been shown to be strong tools for this purpose. Seismic and acoustic signals are affected by a number of target and environmental variables, and since the REMBASS sensors are intended to operate satisfactorily for a large variety of
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20. ABSTRACT (Continued).

targets and terrains, it is recognized that an adequate design will require a signature data base representative of the spectrum of conditions under which the system is to operate.

This report presents a plan for assembling a data base for the development and testing of two types of seismic and acoustic classifying sensors: a sensor for classifying single targets, and a sensor for classifying single targets in a multiple-target environment. The plan also (a) defines the targets to be used in the data collection program, (b) defines the test site conditions to be used in the data collection program and develops a method for relating test site conditions to worldwide environments, (c) establishes a method for assembling a data base of realistic background noise signatures, and (d) specifies the test procedures for signature acquisition from the various target classes. The report includes maps showing predicted worldwide performance of seismic and acoustic sensors and the rationale behind their formulation.

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| 1. REPORT NUMBER<br>Miscellaneous Paper M-76-1 | 2. GOVT ACCESSION NO.<br>AD A021 652 | 3. RECIPIENT'S CATALOG NUMBER |
| 4. TITLE (and Subtitle)<br>PRELIMINARY TESTS OF GLOSS-REDUCTION AND COLORING AGENTS FOR CAMOUFLAGE OF POLYVINYL ACETATE DUST-CONTROL FILM | | 5. TYPE OF REPORT & PERIOD COVERED<br>Final report |
| | | 6. PERFORMING ORG. REPORT NUMBER |
| 7. AUTHOR(s)<br>Clarence R. Styron III<br>Eugene E. Addor | | 8. CONTRACT OR GRANT NUMBER(s) |
| 9. PERFORMING ORGANIZATION NAME AND ADDRESS<br>U. S. Army Engineer Waterways Experiment Station<br>Mobility and Environmental Systems Laboratory<br>P. O. Box 631, Vicksburg, Miss. 39180 | | 10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS<br>Project 1A762719AT40, Task A3, Work Unit 1006 (former 4A762719AT33) |
| 11. CONTROLLING OFFICE NAME AND ADDRESS<br>Office, Chief of Engineers, U. S. Army<br>Washington, D. C. 20314 | | 12. REPORT DATE<br>February 1976 |
| | | 13. NUMBER OF PAGES<br>19 |
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17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Camouflage
Dust control

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

DCA-1295 is a special polyvinyl acetate (PVA) formulation developed for the U. S. Department of the Army for use as a dust-control surface on expedient airstrips and adjacent service areas. The PVA is sprayed over a fiberglass scrim to form a thin film over the ground surface, and has been field tested and proven effective for its design purpose. However, the PVA film cures to a glossy, highly reflective surface that can be easily detected by enemy surveillance systems, is potentially highly attractive to target-seeking missile guidance devices, and sometimes creates hazardous visibility (Continued)

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20. ABSTRACT (Continued)

conditions for aircraft landings. The purpose of the work reported herein was to search for possible means for reducing the glossiness of the cured PVA surface, with the possibility for adding camouflage coloration also considered. A formula was found for mixing colored chalk dust (marking chalk powder) with DCA-1295 concentrate to produce an emulsion that can be painted (brushed, rolled, or sprayed) on the cured, in-place PVA film, and that cures to a tough, nonglossy, colored surface. This formulation formed a good bond with the cured film, and in a field test withstood direct sun and weather for 11 months, well beyond the 6-month design life of the film. In addition, this formulation was also applied, with satisfactory results, to a cured DCA-1295 film (without the fiberglass reinforcement) previously spray-coated onto metal landing mat and fiber membrane. None of the experimental substances (various paint flatteners and extenders, dyes, flat latex paint, and coloring powders) produced satisfactory results when admixed directly with the DCA-1295 emulsion for direct application to the fiberglass scrim during initial installation. It is recommended that the camouflage potential of chalk-dust PVA coating be further evaluated, including its effect on infrared and radar signatures, with particular emphasis on its potential use as a camouflage coating for fixed installations. It is also recommended that research be initiated toward developing a chemically compatible deglossing and coloring agent for inclusion in the DCA-1295 emulsion at its initial application.

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| REPORT DOCUMENTATION PAGE | | READ INSTRUCTIONS BEFORE COMPLETING FORM |
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| 1. REPORT NUMBER<br>Miscellaneous Paper M-76-3 | 2. GOVT ACCESSION NO.<br>AD B010 050L | 3. RECIPIENT'S CATALOG NUMBER |
| 4. TITLE (and Subtitle)<br>TERRAIN CONSTRAINTS ON THE DESIGN, TESTING, AND DEPLOYMENT OF THE GATOR MINE | | 5. TYPE OF REPORT & PERIOD COVERED<br>Final Report<br>6. PERFORMING ORG. REPORT NUMBER |
| 7. AUTHOR(s)<br>Jerry R. Lundien | | 8. CONTRACT OR GRANT NUMBER(s) |
| 9. PERFORMING ORGANIZATION NAME AND ADDRESS<br>Mobility and Environmental Systems Laboratory<br>U. S. Army Engineer Waterways Experiment Station<br>P. O. Box 631, Vicksburg, Miss. 39180 | | 10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS<br>Project No. 2573<br>Task No. CO<br>Work Unit No. 001 |
| 11. CONTROLLING OFFICE NAME AND ADDRESS<br>Deputy for Armament Systems<br>Armament Development and Test Center, Air Force Systems Command, Eglin Air Force Base, Fla. 32542 | | 12. REPORT DATE<br>February 1976<br>13. NUMBER OF PAGES<br>79 |
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17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Computerized models
Mines (ordnance)
Seismic sensors
Terrain analysis
[Eglin AFB, Fla.; Nellis AFB, Nev.; Hopkins, Minn., Vicksburg, Miss.]
[GATOR mine]

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The GATOR mine system consists of two look-alike, air-delivered, target-activated mines. The antitank/antivehicle (AT/AV) mine uses a magnetic sensor, and the antipersonnel (AP) mine utilizes a seismic sensor.

The GATOR mine system has been tested in various terrains within the United States. These tests indicated a non-uniform sensitivity existed in the GATOR AP mine seismic sensor. It was demonstrated that soil characteristics can
(Continued)

20. ABSTRACT (Continued).

affect sensor sensitivity, causing the mine to detonate when the target is beyond warhead lethal range, or causing it not to detonate at all. Thus, its effective use is restricted.

Using computer models that were validated through field studies, this report attempts to predict the expected sensitivity of the GATOR AP seismic sensor. A terrain matrix, made up of elements describing surface and subsurface terrain layers that affect target-induced seismic signal generation and propagation, was developed to define environmental parameter variation. Computer model signals were generated using the matrix results for input to the GATOR mine logic. The results were utilized to define mine performance changes over the environmental parameter ranges. Terrain property combinations which have major effects on source-to-ground energy coupling and seismic signal propagation were evaluated using U. S. Army Engineer Waterways Experiment Station (WES) microseismic generation and propagation models. The models were validated to verify if they could realistically predict, with sufficient sensitivity and reliability, time domain signals versus terrain characteristics. Model validation data were obtained at WES, Vicksburg, Mississippi; Eglin AFB, Florida; Honeywell, Inc., Hopkins, Minnesota; and Nellis AFB, Nevada. The data collected included:

a. HS-10 scientific geophone footstep analog signals.

b. Ground compression and shear wave velocities from refraction seismic surveys.

c. Moisture content, density, and grain-size distribution versus soil depth.

d. Cone index versus soil depth.

e. Surface rigidity.

Predicted digital signals were converted to analog signals and interfaced with the GATOR mine logic at the geophone attachment point. Mine operation was then monitored for similarity with field tests, thus demonstrating a new procedure for defining seismic sensor operational limitations.

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| REPORT DOCUMENTATION PAGE | | READ INSTRUCTIONS BEFORE COMPLETING FORM |
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| 1. REPORT NUMBER<br>Miscellaneous Paper M-76-5 | 2. GOVT ACCESSION NO.<br>AD A023 211 | 3. RECIPIENT'S CATALOG NUMBER |
| 4. TITLE (and Subtitle)<br>COMPUTER-CALCULATED TANK-DEFENDER INTERVISIBILITY ON HUNTER-LIGGETT MILITARY RESERVATION SITES ALPHA AND BRAVO | | 5. TYPE OF REPORT & PERIOD COVERED<br>Final report<br>6. PERFORMING ORG. REPORT NUMBER |
| 7. AUTHOR(s)<br>Victor E. LaGarde<br>Thomas D. Hutto | | 8. CONTRACT OR GRANT NUMBER(s) |
| 9. PERFORMING ORGANIZATION NAME AND ADDRESS<br>U. S. Army Engineer Waterways Experiment Station<br>Mobility and Environmental Systems Laboratory<br>P. O. Box 631, Vicksburg, Miss. 39180 | | 10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS |
| 11. CONTROLLING OFFICE NAME AND ADDRESS<br>U. S. Army Combined Arms Center<br>Fort Leavenworth, Kansas 66027 | | 12. REPORT DATE<br>April 1976<br>13. NUMBER OF PAGES<br>34 |
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18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Computer analysis
Tanks (Combat vehicles)
Visibility
[Hunter-Liggett Military Reservation, California]

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Computer calculations of intervisibility between defender positions and positions along attacking-tank trails were made using the U. S. Army Engineer Waterways Experiment Station Visibility Determination Model. The sites, defensive positions, and attacking-tank trails in this study correspond to those used at Hunter-Liggett Military Reservation in the Tactical Effectiveness Testing of Antitank Missiles program performed by the U. S. Army Combat Developments Experimentation Command.

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ME

| REPORT DOCUMENTATION PAGE | | READ INSTRUCTIONS BEFORE COMPLETING FORM |
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| 1. REPORT NUMBER<br>DNA PR 0023 | 2. GOVT ACCESSION NO.<br>AD B010 489L | 3. RECIPIENT'S CATALOG NUMBER |
| 4. TITLE (and Subtitle)<br>PROJECT ESSEX I<br>Phase 2, Mobility Experiments | | 5. TYPE OF REPORT & PERIOD COVERED<br>Final report covering period from Jul to Sep 1974 |
| | | 6. PERFORMING ORG. REPORT NUMBER<br>Miscellaneous Paper M-76-7 |
| 7. AUTHOR(s)<br>Charles E. Green | | 8. CONTRACT OR GRANT NUMBER(s) |
| 9. PERFORMING ORGANIZATION NAME AND ADDRESS<br>U. S. Army Engineer Waterways Experiment Station<br>Mobility and Environmental Systems Laboratory<br>P. O. Box 631, Vicksburg, Miss. 39180 | | 10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS<br>See Block 18 |
| 11. CONTROLLING OFFICE NAME AND ADDRESS<br>Defense Nuclear Agency<br>Washington, D. C. 20305, and<br>Office, Chief of Engineers, Washington, D. C. 20314 | | 12. REPORT DATE<br>March 1976 |
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17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

This work sponsored by the Defense Nuclear Agency under Subtask L19EAXSX301, Work Unit 002, and by the Office, Chief of Engineers, U. S. Army, under R&D Project 4A162118A880, Task 04, Work Unit 002.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Craters
Mobility
Munition effectiveness
[ESSEX I]
[Fort Polk, Louisiana]

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Project ESSEX I, Phase 2, consisted of the detonation of an 11,249-kg (12.4-ton) charge, a 12,936-kg (14.3-ton) charge, a 10,124-kg (11.2-ton) charge, and an 8,981-kg (9.9-ton) charge of gelled nitromethane with sand at different depths of burial and stemming conditions. The tests were conducted at the Peason Ridge Artillery Range of Fort Polk, Louisiana, at intermittent times from 20 July to October 1974. Mobility experiments were conducted to determine the degree to which the craters and their associated ejecta fields constituted a
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20. ABSTRACT (Continued).

physical barrier to the movement of military vehicles. Four terrain units (2 through 5) in each crater and ejecta area were delineated as significant to ground mobility and described in terms of soil strength, soil moisture content, surface configuration, ejecta depth, and areal extent. The test vehicles, i.e. an M60 tank, an M113A1 armored personnel carrier, and an M715 cargo truck, could operate with ease in all the terrain units except the crater walls (Terrain Unit 4) and the crater floors (Terrain Unit 5). The crater walls were impassable for all the test vehicles because of steep slopes; the crater floors of all the craters except the 12 MU were impassable for the M60 and M715 because of soft soil conditions. The M113A1 could operate on the crater floor of the 3 MU crater. The engineering effort (time required by an HD21 bulldozer) to make the craters passable for the test vehicles was: 10 hours (estimated) on the 6 MWS crater; 5 hours on the 3 MS crater; 1 hour on the 3 MU crater; and 0.30 hour on the 12 MU crater. Degradation of vehicle performance in terms of drawbar-pull coefficient and speed increased for all three test vehicles in each terrain unit from the original surface to GZ. On the basis of degraded area per GJ (0.24 ton) of explosive, the 6 MWS crater was the most effective for the M113A1, and the 3 MU crater was the most effective for the M60 and M715. The 12 MU was the least effective for all three test vehicles. The effective no-go widths for the four craters were in the 46 to 54 metres (151 to 177 feet) range which indicates that similar charges in the same soil conditions would be effective in combat conditions for creating obstacles in this width range. Comparison of measured values and values predicted by AMC-71 (Ground Mobility Model) for four vehicle performance parameters revealed that the overall accuracy of the predictions for go-no go, drawbar pull, motion resistance, and speed was acceptable in every case.

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E

| REPORT DOCUMENTATION PAGE | | READ INSTRUCTIONS BEFORE COMPLETING FORM |
|---|---|---|
| 1. REPORT NUMBER<br>Miscellaneous Paper M-76-9 | 2. GOVT ACCESSION NO.<br>AD A026 598 | 3. RECIPIENT'S CATALOG NUMBER |
| 4. TITLE (and Subtitle)<br>PIXEL PROBLEMS | | 5. TYPE OF REPORT & PERIOD COVERED<br>Final report |
| | | 6. PERFORMING ORG. REPORT NUMBER |
| 7. AUTHOR(s)<br>Warren E. Grabau | | 8. CONTRACT OR GRANT NUMBER(s) |
| 9. PERFORMING ORGANIZATION NAME AND ADDRESS<br>U. S. Army Engineer Waterways Experiment Station<br>Mobility and Environmental Systems Laboratory<br>P. O. Box 631, Vicksburg, Miss. 39180 | | 10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS<br>Project 4A162121A896<br>Task 01, Work Unit 003 |
| 11. CONTROLLING OFFICE NAME AND ADDRESS<br>Office, Chief of Engineers, U. S. Army<br>Washington, D. C. 20314 | | 12. REPORT DATE<br>May 1976 |
| | | 13. NUMBER OF PAGES<br>85 |
| 14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office) | | 15. SECURITY CLASS. (of this report)<br>Unclassified |
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16. DISTRIBUTION STATEMENT (of this Report)

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17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Electromagnetic sensors
Multiband photography
Remote sensing
Terrain
[Pixel]

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)


The exploitation of airborne and satellite-mounted multispectral cameras for the acquisition of terrain information depends upon a detailed understanding of the way in which images are formed by scanner systems, and upon methods of manipulating the radiance values that actually comprise the primary record from which the image is derived. Items discussed include: geometric distortions of the images; relations among pixel size, resolution, and contrast; variations in image geometry caused by mismatches in phase and alignment of pixel arrays;


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20. ABSTRACT (Continued).

variations in image geometry caused by scanning geometry; and variations in image geometry due to pixel shape.

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# REPORT DOCUMENTATION PAGE

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|---|---|---|
| 1. REPORT NUMBER<br>Miscellaneous Paper M-76-10 | 2. GOVT ACCESSION NO.<br>AD A025 333 | 3. RECIPIENT'S CATALOG NUMBER |
| 4. TITLE (and Subtitle)<br>FEASIBILITY OF MONITORING FLOW PATTERNS AND SEDIMENT AND POLLUTANT DISPERSION OF WATER BODIES WITH 24-CHANNEL SPECTRA DATA | | 5. TYPE OF REPORT & PERIOD COVERED<br>Final report<br>6. PERFORMING ORG. REPORT NUMBER |
| 7. AUTHOR(s)<br>Margaret H. Smith | | 8. CONTRACT OR GRANT NUMBER(s) |
| 9. PERFORMING ORGANIZATION NAME AND ADDRESS<br>U. S. Army Engineer Waterways Experiment Station<br>Mobility and Environmental Systems Laboratory<br>P. O. Box 631, Vicksburg, Miss. 39180 | | 10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS<br>Project No. 6.11.01A, 4A061101A91D |
| 11. CONTROLLING OFFICE NAME AND ADDRESS<br>Office, Chief of Engineers, U. S. Army<br>Washington, D. C. 20314 | | 12. REPORT DATE<br>May 1976<br>13. NUMBER OF PAGES<br>55 |
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18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Data processing
Remote sensing
Sensors
Water analyses
Water pollution
[Chesapeake Bay]
[Rappahannock River]

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The primary objective of this research effort was to develop data-handling procedures to transform digital data collected by a Bendix 24-channel airborne sensor into radiance values and to produce images free of skew and reflectance geometry distortion. Data collected over the Chesapeake Bay area on 26 October 1972 and 22 April 1973 at approximately 3200 m and later recorded on computer-compatible tapes (CCT) were studied. Special attention was focused on data from the Rappahannock River. The scanner system, including the mechanics, optics,
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20. ABSTRACT (Continued).

and electronics, is described with an explanation of data formatting on the NASA-generated CCT and the formatting required by existing U. S. Army Engineer Waterways Experiment Station (WES) computer software and programs to handle remotely sensed data, specifically ERTS or LANDSAT CCT data.

Two critical correction problems were encountered, scanning geometry and aircraft attitude. Correction procedures are presented. These were incorporated into a system for 24-channel CCT data conversion by a small computer, PDP 15, and image preparation on an Optronics film writer. A procedure for converting CCT data to radiance at the earth surface was developed, maintaining the relation of radiance to pixel source. Performance problems in the Bendix 24-channel sensor system prevented the completion of an effort to use radiance at the earth surface as a tool to identify varying conditions in or on the water. However, the procedure was developed and has been automated. It is included as an option in the 24-channel data conversion system using the small computer and film writer at WES.

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| REPORT DOCUMENTATION PAGE | | READ INSTRUCTIONS BEFORE COMPLETING FORM |
|---|---|---|
| 1. REPORT NUMBER<br>Miscellaneous Paper M-76-11 | 2. GOVT ACCESSION NO.<br>AD B011 942L | 3. RECIPIENT'S CATALOG NUMBER |
| 4. TITLE (and Subtitle)<br>TERRAIN DESCRIPTION, COVER AND CONCEALMENT CALCULATIONS, AND VEHICLE SPEED PREDICTIONS FOR AMORES | | 5. TYPE OF REPORT & PERIOD COVERED<br>Final report<br>6. PERFORMING ORG. REPORT NUMBER |
| 7. AUTHOR(s)<br>Thomas D. Hutto<br>Harold W. West | | 8. CONTRACT OR GRANT NUMBER(s) |
| 9. PERFORMING ORGANIZATION NAME AND ADDRESS<br>U. S. Army Engineer Waterways Experiment Station<br>Mobility and Environmental Systems Laboratory<br>P. O. Box 631, Vicksburg, Miss. 39180 | | 10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS<br>Army Mortar Requirements Study |
| 11. CONTROLLING OFFICE NAME AND ADDRESS<br>U. S. Army Combined Arms Combat Developments Activity<br>Fort Leavenworth, Kans. 66027 | | 12. REPORT DATE<br>June 1976<br>13. NUMBER OF PAGES<br>58 |
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17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

| | | |
|---|---|---|
| Artillery | Military vehicles | [Army Mortar Requirements Study] |
| Concealment | Terrain analysis | |
| Desert regions | Vehicle speed | |

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The overall purpose of the Army Mortar Requirements Study (AMORES) is to determine whether mortars are the most cost- and operationally-effective means of providing close-in fire support to maneuver battalions in the performance of their assigned missions.

In support of AMORES, a study was conducted to obtain terrain data, cover and concealment data, and calculations of vehicle speeds for seven selected military vehicles for a 20- by 20-km area in the Middle (Continued)

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20. ABSTRACT (Continued)

East. These data are to be used as input to the Carmonette War Game Model by the AMORES team in performing a cost- and operationally-effective analysis on the use of mortars versus alternative indirect-fire weapons (i.e. field artillery).

Maps were prepared that delineate the areal distribution of the numerical class ranges of surface soil strength and associated ground-surface roughness values found in the AMORES area. Maps were also prepared on cover and concealment. These maps delineate the areal distribution of target cover and the amount of concealment provided by the vegetation within the area. Predicted vehicle speeds are provided, as required by the Carmonette Model, for seven military vehicles as functions of the estimated terrain conditions in the AMORES area.

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| 1. REPORT NUMBER<br>Miscellaneous Paper M-76-12 | 2. GOVT ACCESSION NO.<br>AD A026 261 | 3. RECIPIENT'S CATALOG NUMBER |
| 4. TITLE (and Subtitle)<br>A CONCEPT FOR CONSTRUCTING VEGETATION PHYSIOGNOMY | | 5. TYPE OF REPORT & PERIOD COVERED<br>Final report |
| | | 6. PERFORMING ORG. REPORT NUMBER |
| 7. AUTHOR(s)<br>Warren E. Grabau | | 8. CONTRACT OR GRANT NUMBER(s) |
| 9. PERFORMING ORGANIZATION NAME AND ADDRESS<br>U. S. Army Engineer Waterways Experiment Station<br>Mobility and Environmental Systems Laboratory<br>P. O. Box 631, Vicksburg, Miss. 39180 | | 10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS<br>Project 4A061101A91D,<br>Task 02, Work Unit 088 Q6 |
| 11. CONTROLLING OFFICE NAME AND ADDRESS<br>Assistant Secretary of the Army (R&D)<br>Department of the Army<br>Washington, D. C. 20314 | | 12. REPORT DATE<br>June 1976 |
| | | 13. NUMBER OF PAGES<br>94 |
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17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Numerical analysis
Simulation
Trees
Vegetation structure

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

A method is needed for producing numerical descriptions of three-dimensional geometries of tree stands that will approximate descriptions resulting from actual tree-stand measurements. This report presents a concept for mathematically simulating the physiognomy of a single tree, in anticipation of further work toward computer simulation of any specified type of structure, from an individual tree of a given species to a forest composed of some given mix of species.

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20. ABSTRACT (Continued).

The concept described herein is a generalized step-by-step procedure involving dimensions, locations, growth quanta, and direction of stems, branches, and twigs. The result is a line network representing a single tree.

Further work is required to complete and refine the line-network structure before it can be computerized. For example, the simulation procedure needs to have wood placed on the lines, and a systemic procedure must be devised for simulating the tree's self-pruning operation (dead twigs or branches decaying and falling off).

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| REPORT DOCUMENTATION PAGE | | READ INSTRUCTIONS BEFORE COMPLETING FORM |
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| 1. REPORT NUMBER<br>Miscellaneous Paper M-76-13 | 2. GOVT ACCESSION NO.<br>AD A027 369 | 3. RECIPIENT'S CATALOG NUMBER |
| 4. TITLE (and Subtitle)<br>SEISMIC METHODS OF LOCATING MILITARY GROUND TARGETS | | 5. TYPE OF REPORT & PERIOD COVERED<br>Final report |
| | | 6. PERFORMING ORG. REPORT NUMBER |
| 7. AUTHOR(s)<br>Daniel H. Cress | | 8. CONTRACT OR GRANT NUMBER(s) |
| 9. PERFORMING ORGANIZATION NAME AND ADDRESS<br>U. S. Army Engineer Waterways Experiment Station<br>Mobility and Environmental Systems Laboratory<br>P. O. Box 631, Vicksburg, Miss. 39180 | | 10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS<br>Project 1T162112A528<br>Task 02 |
| 11. CONTROLLING OFFICE NAME AND ADDRESS<br>U. S. Army Materiel Development and Readiness Command<br>Alexandria, Va. 22333 | | 12. REPORT DATE<br>June 1976 |
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17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Mechanical waves
Military operations
Seismic investigations
Vehicle signature

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

An approach for locating military ground targets with a triangular array of geophones is presented. An algorithm that relates the characteristics of the signature received at each geophone to the direction of the target is derived. The signatures are then processed by two methods, which have differing degrees of complexity, to estimate target position.

The target-location system (including array deployment) was used in

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20 ABSTRACT (Continued)

field studies to determine directional angles to military targets, including an M113 APC, an M35 2-1/2-ton truck, an M151 jeep, and an M728 (combat engineering vehicle on an M60 tank chassis). A multiple-target test was also analyzed for targets consisting of the M35 and the M151. Estimated and measured angles were then compared.

Results of the analysis indicate that the location of targets using strictly seismic energy and acoustically coupled seismic energy is possible within accuracies of 5 deg and ranges exceeding 450 m. The technique does not appear to be exceedingly sensitive to terrain conditions in view of the results at two geologically dissimilar test sites. However, a thorough study of the sensitivity of the approach to terrain variations is outside the scope of this study.

Appendix A discusses the sensitivity of the directional algorithm to temporal and spatial errors. Appendix B presents a possible technique for locating targets by considering the differences in arrival times of seismic and acoustic waves. Vehicle test conditions are tabulated in Appendix C.

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|---|---|---|
| 1. REPORT NUMBER<br>Miscellaneous Paper M-76-15 | 2. GOVT ACCESSION NO. | 3. RECIPIENT'S CATALOG NUMBER |
| 4. TITLE (and Subtitle)<br>A STUDY OF IMPACT AND PENETRATION OF THE GATOR MINE IN EARTH MATERIALS | | 5. TYPE OF REPORT & PERIOD COVERED<br>Final report; March 1974-September 1974<br>6. PERFORMING ORG. REPORT NUMBER |
| 7. AUTHOR(s)<br>Jerry R. Lundien<br>Charles A. Miller | | 8. CONTRACT OR GRANT NUMBER(s) |
| 9. PERFORMING ORGANIZATION NAME AND ADDRESS<br>U. S. Army Engineer Waterways Experiment Station<br>Mobility and Environmental Systems Laboratory<br>P. O. Box 631, Vicksburg, Miss. 39180 | | 10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS<br>Project No. 2573C001 |
| 11. CONTROLLING OFFICE NAME AND ADDRESS<br>Deputy for Armament Systems (SD3)<br>Armament Development and Test Center<br>Eglin Air Force Base, Fla. 32542 | | 12. REPORT DATE<br>August 1976<br>13. NUMBER OF PAGES<br>68 |
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17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

Also published as Armament Development and Test Center Report ADTC-TR-75-14.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Mines (ordnance)
Penetration resistance (soils)
[Gator Mines]

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report presents the results of a study of the penetration characteristics of an air-delivered, antitank/antivehicle and antipersonnel mine (Gator mine system) as related to variations in mine impact velocity and attitude and changes in soil strength conditions and vegetation. A theoretical study, a field study, and a mapping study were pursued to estimate worldwide mine penetration performance.

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20. ABSTRACT (Continued).

The theoretical results are presented in terms of relations of impact velocity (specific velocity ranges) versus maximum depth of penetration and maximum deceleration for various terrain materials. The field study was conducted using an air gun, and the results are presented in terms of relations of impact velocity, depth of penetration, impact angle, impact attitude, and terrain material strength characteristics. In the mapping study the results of the theoretical and field studies were used to estimate the probability of successful emplacement (i. e., in a position suitable for activation) of the mines in any region of the world.

The results obtained from the theoretical study show that, for the normal range of impact velocity, penetration is excessive in clay and sandy clay soils intermediate in sands, and acceptable in frozen ground and rock. The results obtained from the field study show that penetration was excessive in lean and fat clay soils when the mine impact angle was 90 degrees. Penetration performance becomes more satisfactory as the impact angle decreases. The results of the mapping study show that a large portion of the world has surface soils too soft to allow acceptable emplacement when the impact angle is 90 degrees. Reducing this angle to 45 degrees will allow acceptable emplacement in many regions.

It is recommended that an earth-clearing charge be incorporated into the mine, and that the cross-sectional shape of the mine be modified so that the mine cannot stand on its edge.

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|---|---|---|
| 1. REPORT NUMBER: Miscellaneous Paper M-76-16 | 2. GOVT ACCESSION NO.: AD B013 354L | 3. RECIPIENT'S CATALOG NUMBER |
| 4. TITLE (and Subtitle): A TECHNIQUE FOR ACHIEVING GEOMETRIC ACCORDANCE OF LANDSAT DIGITAL DATA | | 5. TYPE OF REPORT & PERIOD COVERED: Final report |
| | | 6. PERFORMING ORG. REPORT NUMBER |
| 7. AUTHOR(s): James G. Kennedy, Albert N. Williamson | | 8. CONTRACT OR GRANT NUMBER(s) |
| 9. PERFORMING ORGANIZATION NAME AND ADDRESS: U. S. Army Engineer Waterways Experiment Station, Mobility and Environmental Systems Laboratory, P. O. Box 631, Vicksburg, Miss. 39180 | | 10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: Project 4A061101A91D |
| 11. CONTROLLING OFFICE NAME AND ADDRESS: Assistant Secretary of the Army (R & D), Washington, D. C. 20314 | | 12. REPORT DATE: July 1976 |
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17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Computer programs
Mapping
Remote sensing
[LANDSAT (satellite)]

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report presents techniques for precisely overlaying and registering LANDSAT digital data for analysis of time-dependent phenomena. A practical application of the technique is demonstrated by digitally overlaying two LANDSAT scenes of an area, detecting changes that occurred during the intervening period between scenes, and displaying the results as overlays to 1:250,000-scale maps having a UTM projection.

Appendix A to this report presents a method for converting LANDSAT

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20. ABSTRACT (Continued)

computer-compatible tapes to images on photographic film. Appendices B and C present documentation of two of the computer programs used in this study.

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| 1. REPORT NUMBER<br>Miscellaneous Paper M-76-20 | 2. GOVT ACCESSION NO.<br>AD B015 851L | 3. RECIPIENT'S CATALOG NUMBER |
| 4. TITLE (and Subtitle)<br>CONSTRAINTS OF TERRAIN ON DEPLOYMENT OF PATRIOT SYSTEMS | | 5. TYPE OF REPORT & PERIOD COVERED<br>Final report |
| | | 6. PERFORMING ORG. REPORT NUMBER |
| 7. AUTHOR(s)<br>Moody M. Culpepper | | 8. CONTRACT OR GRANT NUMBER(s) |
| 9. PERFORMING ORGANIZATION NAME AND ADDRESS<br>U. S. Army Engineer Waterways Experiment Station<br>Mobility and Environmental Systems Laboratory<br>P. O. Box 631, Vicksburg, Miss. 39180 | | 10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS<br>Project 1T162112A528,<br>Task 02,<br>Work Unit 002 |
| 11. CONTROLLING OFFICE NAME AND ADDRESS<br>U. S. Army Materiel Development and Readiness Command<br>5001 Eisenhower Ave.<br>Alexandria, Va. 22333 | | 12. REPORT DATE<br>November 1976 |
| | | 13. NUMBER OF PAGES<br>38 |
| 14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office) | | 15. SECURITY CLASS. (of this report)<br>Unclassified |
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16. DISTRIBUTION STATEMENT (of this Report)

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17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Projectiles
Site selection
Terrain factor maps
[Patriot (Missile System)]
[West Germany]

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)


A method was formulated for determining the location and distribution of acceptable Patriot sites. The pertinent system deployment characteristics and criteria of acceptability for Patriot sites were determined from data furnished by the Patriot Project Office. To illustrate the use of the method, the pertinent terrain factors and their class intervals were identified and mapped for a study area in West Germany. Road access to the sites was determined, and a

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

20. ABSTRACT (Continued).

road network overlay to the topographic maps was produced that delineates four classes of roads. It appears that there are a relatively large number of acceptable sites accessible to roads in the study area. The line-of-sight between the radar unit and attack aircraft was not determined for the sites mapped as acceptable. However, this should be completed before a final decision on site selection is made. Overlays to topographic base maps were produced for both wet- and dry-season conditions. These overlays show the location and distribution of Patriot sites having four degrees of acceptability.

AD-A043 789    ARMY ENGINEER WATERWAYS EXPERIMENT STATION  VICKSBURG--ETC  F/G 8/13
A BIBLIOGRAPHY WITH ABSTRACTS OF U.S. ARMY ENGINEER WATERWAYS E--ETC(U)
JUN 77  M P MEYER

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4 OF 5
AD
A043 789

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

E

| REPORT DOCUMENTATION PAGE | | READ INSTRUCTIONS BEFORE COMPLETING FORM |
|---|---|---|
| 1. REPORT NUMBER<br>Miscellaneous Paper M-76-21 | 2. GOVT ACCESSION NO. | 3. RECIPIENT'S CATALOG NUMBER |
| 4. TITLE (and Subtitle)<br>CAMOUFLAGE MATERIALS FOR FIXED-INSTALLATION CONCEALMENT | | 5. TYPE OF REPORT & PERIOD COVERED<br>Final report |
| | | 6. PERFORMING ORG. REPORT NUMBER |
| 7. AUTHOR(s)<br>Thomas L. Engdahl | | 8. CONTRACT OR GRANT NUMBER(s) |
| 9. PERFORMING ORGANIZATION NAME AND ADDRESS<br>U. S. Army Engineer Waterways Experiment Station<br>Mobility and Environmental Systems Laboratory<br>P. O. Box 631, Vicksburg, Miss. 39180 | | 10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS<br>Project 4A762719AT40,<br>Task 02, Work Unit 1006 |
| 11. CONTROLLING OFFICE NAME AND ADDRESS<br>Office, Chief of Engineers, U. S. Army<br>Washington, D. C. 20314 | | 12. REPORT DATE<br>December 1976 |
| | | 13. NUMBER OF PAGES<br>202 |
| 14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office) | | 15. SECURITY CLASS. (of this report)<br>Unclassified |
| | | 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE |

16. DISTRIBUTION STATEMENT (of this Report)

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17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Camouglage
Electromagnetic radiation
State-of-the-art studies

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Results are presented of a survey of the state of the art of fixed-installation camouflage, comprising an extensive examination of pertinent literature relating to the subject. The practices of fixed-installation camouflage are reviewed under eight general headings: natural materials, hiding and screening materials, garnishing and texturing materials, supporting materials, coloring materials, ground pattern techniques, decoys, and smoke and aerosol

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

20. ABSTRACT (Continued).

screens. Principles of electromagnetic surveillance are discussed for devices operating from gamma-ray to microwave spectral regions.

A catalog of pertinent camouflage materials, a description of camouflage items, and a comprehensive bibliography are included in Appendixes A, B, and C, respectively.

Unclassified ME
Security Classification

**DOCUMENT CONTROL DATA - R & D**

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1. ORIGINATING ACTIVITY (Corporate author)
U. S. Army Engineer Waterways Experiment Station
Vicksburg, Mississippi

2a. REPORT SECURITY CLASSIFICATION
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2b. GROUP

3. REPORT TITLE
PLAN OF TESTS, TROPICAL SOIL STUDIES

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

5. AUTHOR(S) (First name, middle initial, last name)
Anonymous

6. REPORT DATE
October 1961

7a. TOTAL NO. OF PAGES
72

7b. NO. OF REFS

8a. CONTRACT OR GRANT NO.

b. PROJECT NO.

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9a. ORIGINATOR'S REPORT NUMBER(S)
Instruction Report - Unnumbered

9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)

10. DISTRIBUTION STATEMENT
Approved for public release; distribution unlimited.

11. SUPPLEMENTARY NOTES
Spanish translation of this report is available.

12. SPONSORING MILITARY ACTIVITY
U. S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi

13. ABSTRACT
This report describes the plans for obtaining field data on the engineering characteristics of the soils, vegetation, and topography of selected areas in Central and South America. The data will be used to develop a system for describing and classifying these engineering properties as they manifest themselves in the humid tropics. The data will also be used to develop a method for predicting the changes in moisture content and strength of surface soils that occur on either a daily or a seasonal basis, and to classify areas on the basis of similarity with respect to the engineering properties of their soils. The report discusses the meteorological and soils equipment to be used; the selection, layout, and number of test sites; and the test routines for collecting data at prediction-development and satellite sites. Appendix A presents the field instructions for daily visits and Appendix B provides instructions for computing data.

KEYWORDS: Field tests; Test plans; Test procedures; Trafficability; Tropical regions

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| 1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi | 2a. REPORT SECURITY CLASSIFICATION 2b. GROUP |
| 3. REPORT TITLE PLAN OF TESTS, TROPICAL SOIL STUDIES IN PANAMA AND PUERTO RICO | |
| 4. DESCRIPTIVE NOTES (Type of report and inclusive dates) | |
| 5. AUTHOR(S) (First name, middle initial, last name) Anonymous | |
| 6. REPORT DATE January 1962 | 7a. TOTAL NO. OF PAGES 104 / 7b. NO. OF REFS |
| 8a. CONTRACT OR GRANT NO. b. PROJECT NO. c. d. | 9a. ORIGINATOR'S REPORT NUMBER(S) Instruction Report - Unnumbered 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) |
| 10. DISTRIBUTION STATEMENT Approved for public release; distribution unlimited. | |
| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY U. S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi |

13. ABSTRACT

This plan of tests is part of a comprehensive study to develop quantitative systems for describing and classifying the engineering characteristics of soils, vegetation, and topography of tropical environments, and for predicting their effects on military operations. This plan deals with obtaining information in selected humid-tropical areas in Panama and Puerto Rico. The report discusses the meteorological, soils, and electrical resistance (for soil moisture determinations) equipment to be used; the selection, layout and number of test sites; installation of equipment; and the test routines for collecting data at prediction-development and satellite sites. Appendix A discusses the field instructions for reading the fiberglas electrical resistance units; Appendix B provides instructions for computing data; Appendix C discusses procedures for determining moisture content at saturation and at 60-cm water tension; and Appendix D presents instructions for recording site descriptions.

KEYWORDS: Field tests; Test plans; Test procedures; Trafficability; Tropical regions; [Panama; Puerto Rico]

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| 1. ORIGINATING ACTIVITY (Corporate author)<br>U. S. Army Engineer Waterways Experiment Station<br>Vicksburg, Mississippi | | 2a. REPORT SECURITY CLASSIFICATION<br>Unclassified<br>2b. GROUP |
| 3. REPORT TITLE<br>ENVIRONMENTAL DATA COLLECTION MANUAL: VOLUME V, SURFACE MICROGEOMETRY | | |
| 4. DESCRIPTIVE NOTES (Type of report and inclusive dates)<br>Volume V of a series of volumes | | |
| 5. AUTHOR(S) (Last name, first name, initial)<br>Anonymous | | |
| 6. REPORT DATE<br>September 1965 | 7a. TOTAL NO. OF PAGES<br>38 | 7b. NO. OF REFS<br>0 |
| 8a. CONTRACT OR GRANT NO.<br>b. PROJECT NO. 1-V-0-25001-A-131<br>c.<br>d. | 9a. ORIGINATOR'S REPORT NUMBER(S)<br>Instruction Report 6<br>9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) | |
| 10. AVAILABILITY/LIMITATION NOTICES<br>Approved for public release; distribution unlimited. | | |
| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY<br>U. S. Army Materiel Command | |
| 13. ABSTRACT<br>Detailed instructions are given for the field collection of data describing the configuration of small surface geometry features. Instructions on site selection and the use of relevant instruments are also given.<br><br>KEYWORDS: Manuals; Microgeometry; Test procedures | | |

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**1. ORIGINATING ACTIVITY (Corporate author)**
U. S. Army Engineer Waterways Experiment Station
Vicksburg, Mississippi

**2a. REPORT SECURITY CLASSIFICATION**
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**2b. GROUP**

**3. REPORT TITLE**
INSTRUCTION MANUAL FOR WES TUNNEL EXPLORER LOCATOR SYSTEM

**4. DESCRIPTIVE NOTES (Type of report and inclusive dates)**

**5. AUTHOR(S) (First name, middle initial, last name)**
B. R. Davis, P. A. Smith, and R. E. Riley

| 6. REPORT DATE | 7a. TOTAL NO. OF PAGES | 7b. NO. OF REFS |
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| April 1968 | 45 | |

**8a. CONTRACT OR GRANT NO.**

**b. PROJECT NO.** 1-T-0-21701-A-046

**c.** Task No. 1-7-0-21701-A-046-04

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**9a. ORIGINATOR'S REPORT NUMBER(S)**
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**9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)**

**10. DISTRIBUTION STATEMENT**
Approved for public release; distribution unlimited.

**11. SUPPLEMENTARY NOTES**

**12. SPONSORING MILITARY ACTIVITY**
U. S. Army Materiel Command, Washington, D. C.

**13. ABSTRACT**

This instruction manual was prepared to assist military personnel in the operation and maintenance of the WES Tunnel Explorer Locator System. The system offers the capabilities of (a) two-way communication between personnel inside tunnels and personnel on the surface of the ground and (b) pinpointing the location of personnel inside tunnels who are assigned the task of exploring tunnel complexes.

KEYWORDS: Manuals; Test procedures; Tunnel detection

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| 1. ORIGINATING ACTIVITY (Corporate author)<br>U. S. Army Engineer Waterways Experiment Station<br>Vicksburg, Mississippi | 2a. REPORT SECURITY CLASSIFICATION<br>Unclassified<br>2b. GROUP |

3. REPORT TITLE

ENVIRONMENTAL DATA COLLECTION METHODS; VOLUME IV: VEGETATION; Instruction Manual 1, Vegetation Structure

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Volume IV of a series

5. AUTHOR(S) (First name, middle initial, last name)

| 6. REPORT DATE | 7a. TOTAL NO. OF PAGES | 7b. NO. OF REFS |
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| May 1968 | 104 | 0 |

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| b. PROJECT NO. | Instruction Report No. 10 |
| c. | 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) |
| d. | AD 671 633 |

10. DISTRIBUTION STATEMENT

Approved for public release ; its distribution is unlimited.

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|---|---|
| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY<br>U. S. Army Materiel Command<br>Washington, D. C. |

13. ABSTRACT


This manual provides detailed instructions for collecting quantitative environmental data on vegetation. Included are definitions of terms related to plants and plant assemblages and data recording. Procedures are presented for collecting data. Included are instruction modules for site location and identification, topographic position of site, site photography, vegetation structure, plant nomenclature, and comments.



KEYWORDS: Manuals; Test procedures; Vegetation; Vegetation structure


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|---|---|
| 1. ORIGINATING ACTIVITY (Corporate author)<br>U. S. Army Engineer Waterways Experiment Station<br>Vicksburg, Mississippi | 2a. REPORT SECURITY CLASSIFICATION<br>Unclassified<br>2b. GROUP |
| 3. REPORT TITLE<br>DETERMINATION OF IN-PLACE MOISTURE AND DENSITY BY NUCLEAR METHODS | |
| 4. DESCRIPTIVE NOTES (Type of report and inclusive dates)<br>Final report | |
| 5. AUTHOR(S) (First name, middle initial, last name)<br>Steve L. Webster | |
| 6. REPORT DATE<br>April 1974 | 7a. TOTAL NO. OF PAGES<br>23 / 7b. NO. OF REFS<br>0 |
| 8a. CONTRACT OR GRANT NO.<br>b. PROJECT NO. Q6-1<br>c. Task 06<br>d. Work Unit 002 | 9a. ORIGINATOR'S REPORT NUMBER(S)<br>Instruction Report S-74-1<br>9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)<br>AD 779 422 |
| 10. DISTRIBUTION STATEMENT<br>Approved for public release; distribution unlimited. | |
| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY<br>Office, Chief of Engineers, U. S. Army<br>Washington, D. C. |

13. ABSTRACT Nuclear gages offer a rapid and accurate means for obtaining moisture and density values for a wide variety of materials. Recent advances in the design of nuclear equipment and a better understanding of the nuclear principles involved have led to increasingly widespread use of nuclear gages in earth construction control work. This report describes surface-type nuclear equipment, procedures, and various test methods used for making shallow-depth moisture and density determinations in place on soil and soil-aggregate mixtures. In general, a 6-in. direct transmission density test using a properly operating nuclear gage and an up-to-date factory calibration curve will yield test results slightly better than those of conventional density tests. The factory moisture calibration curve, however, must be checked and adjusted (if necessary) for each material tested. The nuclear test is simpler to perform than conventional tests and requires only about 15 min to obtain both a density and moisture test result.

KEYWORDS: Nuclear equipment; Nuclear methods; Soil aggregates; Soil density measuring devices; Soil moisture measuring devices; Unit weight determination; Water content determination

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## REPORT DOCUMENTATION PAGE

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1. REPORT NUMBER: Instruction Report M-75-1

2. GOVT ACCESSION NO.: AD B004 845L

3. RECIPIENT'S CATALOG NUMBER:

4. TITLE (and Subtitle): AUTOMATED PROCEDURE FOR AIRFIELD SITE EVALUATION

5. TYPE OF REPORT & PERIOD COVERED: Final report

6. PERFORMING ORG. REPORT NUMBER:

7. AUTHOR(s):
Malcolm P. Keown
Judith A. Parks
Jack K. Stoll

8. CONTRACT OR GRANT NUMBER(s):

9. PERFORMING ORGANIZATION NAME AND ADDRESS:
U. S. Army Engineer Waterways Experiment Station
Mobility and Environmental Systems Laboratory
P. O. Box 631, Vicksburg, Miss. 39180

10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: 4A062103A859, Task 05, Work Unit 013, and 4A162121AT31, Task 02, Work Unit 02

11. CONTROLLING OFFICE NAME AND ADDRESS:
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Washington, D. C. 20314

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16. DISTR[illegible]ON STATEMENT (of this Report):
Dist[illegible]n limited to U. S. Government agencies only; computer program doc[illegible]ion; June 1975. Other requests for this document must be referred t[illegible] Engineer Waterways Experiment Station, Vicksburg, Miss., ATTN: W[illegible]

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report):

18. SUPPLEMENTARY NOTES:

19. KEY WORDS (Continue on reverse side if necessary and identify by block number):
Airfield site selection
Airfields
Computer programs
Evaluations
Site investigations

20. ABSTRACT (Continue on reverse side if necessary and identify by block number):

Instructions are provided for the use of a set of related computer programs that collectively represent an automated procedure for airfield site evaluation. Properly used, this set of programs permits evaluation of potential airfield sites in terms of geometry and construction time and cost. Instructions for the collection of the required input data and arrangement of these data into the correct computer input format are provided. The quantity of input data to be collected by the user is minimized by the inclusion of several

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20. ABSTRACT (continued).

tables from which much of the data can be obtained. The output data include relevant airfield geometric parameters and time and cost estimates for the site preparation and runway surfacing phases of airfield construction. These data are interpreted to aid the user in the decision-making process. A discussion of error messages is included to assist the user in eliminating problems related to input data.

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

EP

# REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

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|---|---|
| 1. REPORT NUMBER: Instruction Report M-76-1 | 2. GOVT ACCESSION NO.: V.1 AD A030 173; V.2 AD B013 638L |
| 3. RECIPIENT'S CATALOG NUMBER | |
| 4. TITLE (and Subtitle): AUTOMATED PROCEDURE FOR EVALUATING SITES FOR SUITABILITY AS HELICOPTER LANDING ZONES | 5. TYPE OF REPORT & PERIOD COVERED: Final report |
| | 6. PERFORMING ORG. REPORT NUMBER |
| 7. AUTHOR(s): Judith A. Parks | 8. CONTRACT OR GRANT NUMBER(s) |
| 9. PERFORMING ORGANIZATION NAME AND ADDRESS: U. S. Army Engineer Waterways Experiment Station, Mobility and Environmental Systems Laboratory, P. O. Box 631, Vicksburg, Miss. 39180 | 10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: Project No. 4A162121AT31, Task 02, Work Unit 02 and No. 1T162112A528, Task 02, Work Unit 02 |
| 11. CONTROLLING OFFICE NAME AND ADDRESS: Office, Chief of Engineers, U. S. Army, Washington, D. C. 20314 and U. S. Army Materiel Development and Readiness Command, Alexandria, Virginia 22333 | 12. REPORT DATE: June 1976 |
| | 13. NUMBER OF PAGES: 315 |
| 14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office) | 15. SECURITY CLASS. (of this report): Unclassified |
| | 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE |

16. DISTRIBUTION STATEMENT (of this Report)

Volume I--Approved for public release; distribution unlimited.
Volume II--Distribution limited to U. S. Government agencies only; computer program documentation; June 1976. Other requests for this document must be referred to U. S. Army Engineer Waterways Experiment Station (WESFE)

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

Volume I--Description and Instructions for Use of Computer Programs
Volume II--Listings of Computer Programs

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

| | |
|---|---|
| Aircraft landing areas | Helicopter landing zones |
| Airfield site selection | Mathematical models |
| Computer programs | Site selection |

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)


This report contains instructions for operating a model that is an automated procedure for evaluating designated sites as helicopter landing zones. The model is comprised of three independent computer programs run sequentially.

Program 1 (FTHEL) evaluates the site in terms of generalized conditions


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20. ABSTRACT (Continued).

of slope, microrelief, and soil strength as related to the requirements set by certain characteristics of the helicopter that is to land. The program determines whether the site can provide a full-touch zone, a skid-touch zone, a nontouch zone, or no landing zone at all, and computes the minimum departure angle for the specified helicopter if a landing zone is possible.

Program 2 (FTJPRH) is an automated mathematical procedure for predicting the size and shape of a clearing in a forested area by considering blast forces from a bomb explosion, tree stem strength, stem diameter, and distance from ground zero (GZ), the center of the explosion. The clearing is described by a vegetation profile of tree remnant height versus the distance from GZ.

Program 3 (FTJPHL) of the model is an automated procedure for evaluating a clearing by estimating how many trees must be removed from a clearing produced by a high-yield, air-dropped munition in order to use the clearing as a full-touch helicopter landing zone. The output is the number of tree remnants that must be removed to satisfy the landing requirements of a specified helicopter.

All three computer programs were designed and written for use on a Honeywell G-635 computer system equipped with extensive time-sharing capability, coded in FORTRAN language, and run in conversational mode by means of a conventional teletype terminal. Maximum core storage for any one program is 10K words.

This report is intended to serve as a guidebook for the individual responsible for running the programs and requires a working knowledge of computer techniques and terminology and various methods pertinent to data processing.

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

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| REPORT DOCUMENTATION PAGE | | READ INSTRUCTIONS BEFORE COMPLETING FORM |
|---|---|---|
| 1. REPORT NUMBER<br>PSTIAC Report No. 1 | 2. GOVT ACCESSION NO.<br>AD A011 269 | 3. RECIPIENT'S CATALOG NUMBER |
| 4. TITLE (and Subtitle)<br>MICROTHESAURUS OF VEHICLE MOBILITY, ENVIRONMENT, AND PAVEMENT TERMS | | 5. TYPE OF REPORT & PERIOD COVERED<br><br>6. PERFORMING ORG. REPORT NUMBER |
| 7. AUTHOR(s) | | 8. CONTRACT OR GRANT NUMBER(s) |
| 9. PERFORMING ORGANIZATION NAME AND ADDRESS<br>U. S. Army Engineer Waterways Experiment Station<br>P. O. Box 631<br>Vicksburg, Mississippi 39180 | | 10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS<br>Project 1E865803M761/05 |
| 11. CONTROLLING OFFICE NAME AND ADDRESS<br>U. S. Army Materiel Command<br>AMCRD-EM<br>Alexandria, Virginia 22333 | | 12. REPORT DATE<br>April 1975<br>13. NUMBER OF PAGES<br>132 |
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18. SUPPLEMENTARY NOTES

Prepared as a joint project of the Pavements and Soil Trafficability Information Analysis Center and Technical Information Center, USAEWES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Environment terminology
Microthesauri
Mobility terminology
Pavements terminology
Subject index terms
Thesauri
Vehicle terminology

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The terms in the microthesaurus cover three major areas of interest: vehicle mobility, environment, and pavements, as related primarily to military research. Non-technical terms common to all subject areas in research and development are included to provide a complete vocabulary of concepts. The microthesaurus will become part of a larger version encompassing several subject areas of particular interest at the U. S. Army Engineer Waterways Experiment Station. The format, rules, and conventions used in this document generally follow

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those recommended by the Committee on Scientific and Technical Information (COSATI), and used in the Thesaurus of Engineering and Scientific Terms (TEST).

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M, E

| REPORT DOCUMENTATION PAGE | | READ INSTRUCTIONS BEFORE COMPLETING FORM |
|---|---|---|
| 1. REPORT NUMBER<br>PSTIAC Report No. 2 | 2. GOVT ACCESSION NO.<br>AD A018 290 | 3. RECIPIENT'S CATALOG NUMBER |
| 4. TITLE (and Subtitle)<br>BIBLIOGRAPHY OF PAPERS PRESENTED AT MEETINGS OR IN TECHNICAL JOURNALS ON STUDIES OF THE MOBILITY AND ENVIRONMENTAL SYSTEMS LABORATORY | | 5. TYPE OF REPORT & PERIOD COVERED<br>6. PERFORMING ORG. REPORT NUMBER |
| 7. AUTHOR(s)<br>Marvin P. Meyer | | 8. CONTRACT OR GRANT NUMBER(s) |
| 9. PERFORMING ORGANIZATION NAME AND ADDRESS<br>U. S. Army Engineer Waterways Experiment Station<br>Pavements and Soil Trafficability Information Analysis Center<br>P. O. Box 631, Vicksburg, Miss. 39180 | | 10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS<br>Project 1T865803M761/05 |
| | | 12. REPORT DATE<br>November 1975 |
| 11. CONTROLLING OFFICE NAME AND ADDRESS<br>U. S. Army Materiel Command<br>5001 Eisenhower Ave., Alexander, Va. 22333 | | 13. NUMBER OF PAGES<br>30 |
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16. DISTRIBUTION STATEMENT (of this Report)

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17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Environment bibliography
Mobility bibliography
Trafficability bibliography
Vehicle bibliography

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report presents a bibliography of papers related to activities of the Mobility and Environmental Systems Laboratory of the U. S. Army Engineer Waterways Experiment Station published in technical journals, special publications, transactions, or proceedings, or presented at meetings, symposiums, or conferences from June 1955 through November 1974. A subject index is included.

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3. REPORT TITLE

APPLICATION OF AIRPHOTO PATTERN ANALYSIS TO SOIL TRAFFICABILITY STUDIES: Books 1-6, Supplements 1 and 2

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

5. AUTHOR(S) (First name, middle initial, last name)

R. E. Frost, et al

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10. DISTRIBUTION STATEMENT

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| 11. SUPPLEMENTARY NOTES<br>The information contained herein is summarized in WES Technical Report No. 3-331, Report 6, Vols 1 and 2 | 12. SPONSORING MILITARY ACTIVITY<br>U. S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi |

13. ABSTRACT

The studies reported herein are part of a comprehensive effort begun in 1949 to develop techniques for estimating the trafficability of soil by remote means. They are devoted specifically to development of techniques for analyzing and interpreting vertical aerial photographs for soil trafficability purposes. To provide a basis for these studies, airphoto and soil trafficability data were collected in each of several representative landscapes over a period of several years by Purdue University and the Waterways Experiment Station personnel. Trafficability data were collected at sites in 33 humid climate states and 2 arid climate states. Book 1 (Application of Airphoto Pattern Analysis to Soil Trafficability Studies, Jun 51) discusses the airphoto pattern analysis procedure and the relationships between trafficability measurements and airphoto patterns. A description of regional drainage, topography, local erosion, natural vegetation, cultural practices, parent material, soil profile, and trafficability and cross-country movement characteristics is presented for each of several landscapes in Books 2 (Glaciated Deposited Materials, Jun 51), 3 (Water Deposited Materials, Dec 52), 4 (Miscellaneous Materials, Jun 51), 5 (Eolian Materials, Mar 54), and 6 (Residual Materials, Jun 54). Additional information on the trafficability characteristics of the landscapes is presented in Supplement 1 (Sep 56) and Supplement 2 (Glacial Deposited Materials, Dec 57).

KEYWORDS: Airphoto interpretation; Trafficability prediction

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| 3. REPORT TITLE <br> THE DEVELOPMENT OF METHODS FOR PREDICTING SOIL MOISTURE CONTENT, Progress Report No. I, Vol. I-II | |
| 4. DESCRIPTIVE NOTES (Type of report and inclusive dates) <br> Progress report from 1 Apr - 1 Oct 1951 | |
| 5. AUTHOR(S) (First name, middle initial, last name) <br> E. J. Dortignac and H. W. Lull | |
| 6. REPORT DATE <br> November 1951 | 7a. TOTAL NO. OF PAGES <br> 57 <br> 7b. NO. OF REFS <br> 9 |
| 8a. CONTRACT OR GRANT NO. <br> b. PROJECT NO. <br> c. <br> d. | 9a. ORIGINATOR'S REPORT NUMBER(S) <br> 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) <br> WES Contract Report No. 4-8, Progress Report No. I, Vols I-II |
| 10. DISTRIBUTION STATEMENT <br> Approved for public release; distribution unlimited. | |
| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY <br> U. S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi |

13. ABSTRACT

Methods of predicting soil moisture content were developed for three sites in the Vicksburg area, Park, Rifle and Mound. Basic data from which to develop prediction methods consisted of a daily record of soil moisture from 1 April to 1 October 1951, for each site and concurrent data on rainfall, air and soil temperature, humidity and wind movement. Development and density of vegetation were checked periodically. Soil studies included profile descriptions and determination of texture, bulk density, moisture content at wilting point and field capacity, and soil moisture-tension relations. The soil moisture record consisted of a daily inventory of soil moisture content at 8 to 10 depths in the upper 42 in. This record was obtained with the Colman soil moisture meter and fiberglas units. Soil moisture contents were predicted at the 6- to 15-in. depth. The amount of soil moisture accretion at this depth following rainfall was found to be dependent on the relation between storm size and available storage. Depletion curves in the soil moisture record were very similar throughout the entire period. Average depletion prediction curves were developed for each 3-in. layer from 0 to 15 in. Depletion rates, in general, were exponential in form with rates of loss tending to decrease with depth. No relation was found between depletion rates and air and soil temperatures, humidity, wind and vegetation composition. The accretion and depletion methods were combined to predict soil moisture content for the period of record. Consistent agreements were obtained between actual and predicted values of soil moisture content.

KEYWORDS: Soil moisture prediction; Temperate regions; Trafficability; [Vicksburg, Miss.

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3. REPORT TITLE

THE DEVELOPMENT OF METHODS FOR PREDICTING SOIL MOISTURE CONTENT, Progress Report II

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Progress report from 1 Oct 51 - 1 Apr 52

5. AUTHOR(S) (First name, middle initial, last name)

H. W. Lull, et al

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| 6. REPORT DATE July 1952 | 7a. TOTAL NO. OF PAGES 177 | 7b. NO. OF REFS |
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| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY U. S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi |

13. ABSTRACT

Prediction methods for the period October 1951 to April 1952, the "Winter" season, were developed for the same three sites (Park, Rifle, and Mound, Vicksburg, Miss.) as reported in Progress Report I for the summer season. Basic data from which to develop prediction methods consisted of a daily record of soil moisture, water table records, and concurrent data on rainfall, air and soil temperatures, humidity and wind movement. Condition of vegetation was checked periodically; soils were classified. As in the summer season, soil moisture accretion during winter was found to be dependent on storm size and available storage. For the major part of the period depletion rates were markedly below summer rates. Following rainfalls that saturated the soil, one to two days were required to drain to field capacity; further depletion proceeded at a very slow fairly constant rate. Rates decreased with depth. High water tables affected accretion and helped to maintain high moisture contents. The accretion and depletion methods were combined to predict soil moisture content for the period of record. Consistent agreements were obtained between actual and predicted values of soil moisture content. Summer soil moisture depletion data in Progress Report I were reevaluated and a search of literature made to determine soil moisture depletion rates from other areas. Results of six special studies dealing with instrumentation, calibration of soil moisture units and interrelationships of soil moisture to volume weight and root concentration are reported.

KEYWORDS: Soil moisture prediction; Temperate regions; Trafficability; [Vicksburg, Miss.]

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3. REPORT TITLE

ANALOGS OF YUMA CLIMATE IN THE MIDDLE EAST
YUMA ANALOGS NO. I

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

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5. AUTHOR(S) (Last name, first name, initial)

Ohman, Howard L.
Porter, William F.
Robison, William C.

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13. ABSTRACT The climate of the Middle East has strong resemblance to that of Yuma, Arizona. The similarity is particularly close in all important respects, both winter and summer, in the valley of the Jordan River in Israel and Jordan, and in the southern part of the Mesopotamian lowland between Baghdad and Basra. Although these areas of close analogy are of small extent, areas in which single elements of the climate, such as winter temperatures, summer temperatures, and annual precipitation, are analogous include considerable parts of the Middle East. When areas that may be considered semianalogous are added to these, certain climatic elements are found to be more or less comparable to Yuma over most of the Middle East region. This is especially true of precipitation, as only the Mediterranean coast and the highlands around the margins of the region have a mean annual precipitation in excess of the amount adopted here as the limit of semianalogy. The yearly distribution of precipitation, however, is roughly comparable to that of Yuma only on the south coast of Arabia where rain is received in both summer and winter. Average and extreme values for summer and winter temperatures are closely analogous to those at Yuma over considerable areas, although these seasonally analogous zones overlap only in interior Arabia, southern Iraq, and the Dead Sea Rift Valley. Of the climatic elements considered here, the July mean dewpoint temperature has the most restricted area of analogy; such areas were found to exist only in a relatively narrow band near the coasts and in the Syrian plateau, in addition to the two areas of complete analogy. Maps, tables

KEYWORDS: Climatic analogs; Climatology; Desert regions; [Middle East, Yuma, Arizona]

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3. REPORT TITLE

ANALOGS OF YUMA CLIMATE IN NORTHEAST AFRICA
YUMA ANALOGS NO. 2

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Contract Report

5. AUTHOR(S) (Last name, first name, initial)

Anonymous

| 6. REPORT DATE | 7a. TOTAL NO. OF PAGES | 7b. NO. OF REFS |
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| 8a. CONTRACT OR GRANT NO.<br>b. PROJECT NO.<br>8-97-10-004<br>c.<br>d. | 9a. ORIGINATOR'S REPORT NUMBER(S)<br>9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)<br>WES Contract Report 3-11, No.2 |

10. AVAILABILITY/LIMITATION NOTICES

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| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY |
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13. ABSTRACT

Northeast Africa has considerable areas where the important climatic elements are closely analogous to those at Yuma, Arizona, although there are few if any places where these all coincide. Temperatures of the coldest month are analogous over about the northern two-thirds of the region, reaching the Mediterranean Coast in most places. Areas where temperatures of the warmest month are analogous do not lie so far north but extend southward beyond the southern limits of aridity, merging into the perennially hot tropical regions. In the interior, only the higher elevations of the Tibesti Mountains and the highlands of Ennedi and Darfur are too cool to be included. Analogous areas of the other elements plotted--mean annual precipitation, mean dew point for July, and mean cloudiness for July--are confined to two transverse bands of varying width, one in the north paralleling the Mediterranean coast and one in the south in the transitional area where desert gives way to tropical steppe. Areas of analogous dew points are also found in a narrow band paralleling the Red Sea coast. The vast interior of Northeast Africa is practically rainless and for this reason is semianalogous to Yuma, where several inches usually fall each year. In the two bands where mean annual precipitation is closely analogous the seasonal distribution is quite different from that of Yuma, as both zones have definite wet and dry seasons and the rainfall is confined to certain months of the year; only on the Red Sea coast near Port Sudan is the rainfall distributed throughout the year as it is at Yuma. The interior of the region is not only more arid than the Yuma desert but also has lower dew points, less cloud throughout the year, and lighter winds most of the time.

KEYWORDS: Climatic analogs; Climatology; Desert regions; [Northeast Africa, Yuma, Arizona]

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3. REPORT TITLE
ANALOGS OF YUMA CLIMATE IN NORTHEAST AFRICA
YUMA ANALOGS NO. 3

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
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5. AUTHOR(S) (Last name, first name, initial)
Anonymous

| 6. REPORT DATE | 7a. TOTAL NO. OF PAGES | 7b. NO. OF REFS |
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| c. | 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) |
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10. AVAILABILITY/LIMITATION NOTICES
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| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY |
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| | WES |

13. ABSTRACT The portions of Northwest Africa in which temperatures are analogous to those at Yuma in both winter and summer are limited to a strip on the interior side of the Atlas Mountains, and a second strip nearly surrounding the Ahaggar Mountains and adjoining the large area of composite analogy in Libya. Large parts of the study area are not analogous in either summer or winter, owing to the exclusion of the large western Sahara as too hot, and the mountainous regions of the Atlas ranges and the Ahaggar as too cool. Likewise, the entire Atlantic coast south of the 32nd parallel of latitude is too cool to be analogous in either summer or winter. There remain substantial areas in which temperatures are analogous in summer or winter, but not both, although these are less extensive than in Northeast Africa. When areas of analogous mean annual precipitation, occurring as two transverse bands, are superimposed on the map of composite temperature analogy, zones of coincidence are found along the desert piedmont of the Atlas Mountains, including a large section west of the Gulf of Gabes, and farther south in the Air Highlands. The vast, nearly rainless interior of the Sahara is drier than Yuma everywhere except in a few elevated places. Rainfall is quite different from Yuma with respect to seasonality, having a pronounced winter maximum in the north and summer maximum at Yuma. Conditions of dew point and cloudiness comparable to those of Yuma in July are found in transverse bands in Northwest Africa, bordering the Sahara like those of analogous rainfall. The interior Sahara is less humid and even more sunny than Yuma. Winds in the interior desert are predominantly lighter than at Yuma, although sandstorms are more frequent. Of the elements studied, mean daily temperature range in the warmest month shows the largest area of values comparable to Yuma, covering much of Northwest Africa exclusive of the immediate coasts. Maps, tables

KEYWORDS: Climatic analogs; Climatology; Desert regions; [Northwest Africa; Yuma, Arizona]

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3. REPORT TITLE

ANALOGS OF YUMA CLIMATE IN SOUTH CENTRAL ASIA (INDIA, PAKISTAN, AFGHANISTAN, IRAN)
YUMA ANALOGS NO. 4

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Contract Report

5. AUTHOR(S) (Last name, first name, initial)

Robison, William C.; Dodd, Arthur V.

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| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY |
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13. ABSTRACT Extensive areas of South Central Asia have summer temperatures analogous to those at Yuma. Only in the extremely hot Indus Valley of Pakistan and the interior basins of Iran, and in the perennially cool mountains of Kashmir, Afghanistan, and northern Iran are summer temperature regimes appreciably different from those at Yuma. In winter, however, the area of temperature analogy is restricted by the occurrence of temperatures higher than at Yuma in the southern part of the Indian lowlands, and by the occurrence of lower temperatures in the elevated interior of Iran. Mean annual precipitation falls within some degree of analogy (i.e., less than 9 inches) over most of the study area. The only areas with higher rainfall are the lowland portion of India subject to monsoon rains, the northwestern part of Iran bordering the Caspian Sea, and some of the higher mountains. The combined areas of analogy and semianalogy for mean July cloudiness are approximately the same as for mean annual precipitation. Mean July wind speeds are likewise analogous or or semianalogous at most of the stations for which values are available, being too high only at some of the coastal stations and in the vicinity of the Seistan Basin near the center of the region. Summer dew points are analogous in a comparatively narrow band between the humid regions that are subject to maritime influences, and the dry highland regions of Kashmir, Afghanistan, and Iran. This analogous band is widest in western Baluchistan and swings northwest near the Persian Gulf coast to the northwestern border of Iran. The greatest coincidence of analogy of combined climatic elements is in western Baluchistan as shown by the records of Panjgur; a similar area of nearly total analogy is found in the Indus River Valley of West Pakistan in the vicinity of Bahawalpur. The results of the study are summarized in a series of maps at the end of the report. Maps, tables

KEYWORDS: Climatic analogs; Climatology; Desert regions; [South Central Asia; Yuma, Arizona]

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3. REPORT TITLE
ANALOGS OF YUMA CLIMATE IN SOVIET MIDDLE ASIA
YUMA ANALOGS NO. 5

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
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5. AUTHOR(S) (Last name, first name, initial)
Robison, William C.; Dodd, Arthur V.

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10. AVAILABILITY/LIMITATION NOTICES

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| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY |
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| | WES |

13. ABSTRACT All of Soviet Middle Asia is north of the latitude of Yuma, and most of it is, therefore, too cool for temperature analogy with Yuma. In the extreme south, however, two areas have summer temperatures high enough to be analogous. Winters are much colder than at Yuma. Mean annual precipitation is analogous (i.e., two to six inches) over a large area extending from the Caspian Sea to the foot of the Tien Shan. Approximately the same area is analogous or semianalogous to Yuma in respect to mean July cloud cover, with less than three tenths of sky cover. Mean July wind speeds are analogous or semianalogous (less than 12 mph) at all stations for which data are available except Baku on the Caspian Coast, where a mean of 14 mph is recorded. Summer dew points are analogous in the southwestern portion of the study area, including the Aral Sea and Caspian Sea regions. The greatest coincidence of analogy of combined climatic elements is in the extreme southern portion of the study area. Termez on the Afghanistan border has the climate most similar to that at Yuma; only the occurrence of lower winter temperatures at Termez prevents analogy of all climatic elements investigated. Areas of analogy of pertinent climatic elements are presented in a series of maps at the end of the report. Maps, tables

KEYWORDS: Climatic analogs; Climatology; Desert regions; [Soviet Middle Asia; Yuma, Arizona]

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| 3. REPORT TITLE ANALOGS OF YUMA CLIMATE IN CHINESE INNER ASIA YUMA ANALOGS NO. 6 | |
| 4. DESCRIPTIVE NOTES (Type of report and inclusive dates) Contract Report | |
| 5. AUTHOR(S) (Last name, first name, initial) Robison, William C.; Dodd, Arthur V. | |

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10. AVAILABILITY/LIMITATION NOTICES

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| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY WES |

13. ABSTRACT No part of Chinese Inner Asia is climatically analogous to Yuma in both winter and summer. Winters are far too cold everywhere to be considered analogous, and summers are too cool in most places, but in summer one small area-the Turfan Depression in Sinkiang--is much like Yuma in respect to temperature and precipitation. Considering only mean temperature for the warmest month, for which the Yuma value is 91°F, the area of comparability (within 5°F) also includes the valley of the Wei Ho in Shensi province. A large portion of the study area has mean annual precipitation between two and six inches, and is therefore considered analogous to the Yuma mean of 3.4 inches. Much of the Tarim Basin has a mean of less than two inches, and is thus semianalogous to Yuma. The entire area has mean cloudiness greater than 3.0 in July, too high to be analogous to the Yuma average of 1.6 tenths. Mean July wind speeds are analogous or semianalogous (less than 12 mph) at all stations for which data are available. Most of Chinese Inner Asia has lower dew points than Yuma; only in the more humid southeast are dew points of the same order as or higher than the August value of 64°F at Yuma. Areas of analogy of pertinent climatic elements are presented in a series of maps at the end of the report. Maps, tables

KEYWORDS: Climatic analogs; Climatology; Desert regions; [Chinese Inner Asia; Yuma, Arizona]

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3. REPORT TITLE

ANALOGS OF YUMA CLIMATE IN EAST CENTRAL AFRICA
YUMA ANALOGS NO. 7

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

5. AUTHOR(S) (Last name, first name, initial)

Nelson, Ronald A.

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| | WES |

13. ABSTRACT

In East Central Africa, climatic analogies with Yuma for most elements are restricted to relatively small areas. Temperatures during the warmest month are analogous along the narrow coastal strip that borders the Red Sea and Gulf of Aden, and in sections of interior Somalia and Kenya. The interior highlands are too cool for analogy during the warmest month, but in the coldest month have analogous temperatures at elevations above approximately 6000 ft. Owing to the greater annual range at Yuma, there is no overlap in East Central Africa between areas of temperature analogy for the warmest and coldest months. Areas of analogous mean annual precipitation (2 to 6 in.) coincide largely with the coastal area of warmest month analogy, and occur in the interior only in an isolated pocket adjacent to Lake Rudolf. Mean annual rainfall is less than 2 in. (semianalogous, drier) in two narrow coastal areas of Eritrea and British Somaliland. In the interior highlands rainfall is generally high. Mean dew points are considerably higher in the coastal areas than at Yuma, and are analogous only at the intermediate elevations of the interior. Mean cloudiness in July is analogous or semianalogous in the lowland regions adjacent to the Red Sea and Gulf of Aden, and on the northern coast of Somalia. In July, wind speeds are analogous at both coastal and inland stations within Eritrea, and at several stations along the Ethiopian-Sudanese border; elsewhere, wind data are largely lacking. Within East Central Africa, there is no complete all-year analogy to Yuma climate. However, the coastal plain bordering the Red Sea and the Gulf of Aden resembles Yuma in many respects and is the closest counterpart to be found within the study area.
Maps, tables

KEYWORDS: Climatic analogs; Climatology; Desert regions; [East Central Africa; Yuma, Arizona]

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| (Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified) | | |
| 1. ORIGINATING ACTIVITY (Corporate author) Headquarters, Quartermaster Research and Development Command, U. S. Army Natick, Mass. | 2a. REPORT SECURITY CLASSIFICATION Unclassified | |
| | 2b. GROUP | |
| 3. REPORT TITLE ANALOGS OF YUMA CLIMATE IN NORTH AMERICA YUMA ANALOGS NO. 8 | | |
| 4. DESCRIPTIVE NOTES (Type of report and inclusive dates) Contract Report | | |
| 5. AUTHOR(S) (Last name, first name, initial) Nelson, Ronald A. | | |
| 6. REPORT DATE January 1957 | 7a. TOTAL NO. OF PAGES 25 | 7b. NO. OF REFS 28 |
| 8a. CONTRACT OR GRANT NO. | 9a. ORIGINATOR'S REPORT NUMBER(S) | |
| b. PROJECT NO. 8-97-10-004 | | |
| c. | 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) | |
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| 10. AVAILABILITY/LIMITATION NOTICES Approved for public release; distribution unlimited. | | |
| 11. SUPPLEMENTARY NOTES Project Reference 7-83-01-001B | 12. SPONSORING MILITARY ACTIVITY WES | |

13. ABSTRACT A core area of close analogy to the Yuma climate exists in southeastern California, southwestern Arizona, and in adjoining parts of Mexico. Warmest month temperature analogy occurs generally in the arid and semiarid regions of the study area. Coldest month temperature analogy occurs generally in the lower latitudes of the study area. Along the western littoral of the United States, which is relatively warm in winter, close temperature analogy extends to approximately 38° North. Areas of precipitation analogy coincide closely with the Sonoran and Mojave Deserts, and several small areas are also closely analogous. Only Death Valley is significantly drier. Mean dew points for the highest month are analogous to those at Yuma in the Great Plains, zones between mountains and coasts in most of Mexico, coastal Baja California and southern California, and the Sonoran Desert. Analogy for mean cloudiness is restricted to the Sonoran and Mojave Deserts, the Central Valley of California, and central Baja California. Analogous wind speeds are distributed generally over most of the study area, but local terrain differences cause much variation in speed and direction. Areas of analogy of pertinent climatic elements are presented in a series of maps at the nd of the report.

aps, tables

KEYWORDS: Climatic analogs; Climatology; Desert regions; [North America; Yuma, Arizona]

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|---|---|
| 1. ORIGINATING ACTIVITY (Corporate author)<br>Purdue University<br>Engineering Experiment Station<br>Lafayette, Indiana | 2a. REPORT SECURITY CLASSIFICATION<br>Unclassified<br>2b. GROUP |

3. REPORT TITLE

EFFECT OF SOIL MOISTURE AND OTHER NATURAL VARIABLES ON AERIAL PHOTO GRAY TONES

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Contract Report

5. AUTHOR(S) (First name, middle initial, last name)

Adolph G. Altschaeffl

| 6. REPORT DATE | 7a. TOTAL NO. OF PAGES | 7b. NO. OF REFS |
|---|---|---|
| October 1954 | 78 | 17 |

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| 8a. CONTRACT OR GRANT NO. DA-22-079-eng-59<br>DA Project No. 8-70-05-001<br>b. PROJECT NO.<br>c.<br>d. | 9a. ORIGINATOR'S REPORT NUMBER(S)<br><br>9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)<br>WES Contract Report 4-12A |

10. DISTRIBUTION STATEMENT

Approved for public release; distribution unlimited.

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| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY<br>U. S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi |

13. ABSTRACT

The study reported has the purpose of determining the effect of soil moisture and other natural variables on aerial photo gray tones. A discussion of the numerous factors involved in the production of gray tones is presented. Soil moisture, surface soil color, vegetation, and flight altitude and direction are given emphasis. An attempt is made to correlate soil moisture content with gray tone quality. Gray tone quality is measured by the transmission density of the aerial negative at any desired location. Soil moisture prediction from aerial negatives is also attempted and the results reported. Numerical methods of analysis, rank correlations and product-moment correlations, are used in the attempted correlations reported. Predictions of soil moisture contents from aerial negatives alone are feasible, but the improvement of the accuracy of these predictions is needed. Approximately 30 to 60 percent of the variation in density readings may be attributed to variations in soil moisture contents.

KEYWORDS: Airphoto interpretation; Soil moisture prediction

DD FORM 1 NOV 65 1473 REPLACES DD FORM 1473, 1 JAN 64, WHICH IS OBSOLETE FOR ARMY USE.

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Security Classification

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|---|---|
| 1. ORIGINATING ACTIVITY (Corporate author)<br>George Washington University<br>School of Engineering<br>Washington, D. C. | 2a. REPORT SECURITY CLASSIFICATION<br>Unclassified<br>2b. GROUP |

3. REPORT TITLE

CODING HANDBOOK

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Contract Report (revised edition)

5. AUTHOR(S) (Last name, first name, initial)

Anonymous

| 6. REPORT DATE | 7a. TOTAL NO. OF PAGES | 7b. NO. OF REFS |
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| 1 December 1954 | 15[illegible] | |

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| 8a. CONTRACT OR GRANT NO.<br>DA 22-079-eng-141<br>b. PROJECT NO. | 9a. ORIGINATOR'S REPORT NUMBER(S) |
| c.<br>d. | 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)<br>WES Contract Report 3-13 |

10. AVAILABILITY/LIMITATION NOTICES

Approved for public release; distribution unlimited.

| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY |
|---|---|
| | WES |

13. ABSTRACT


This report describes a system of digital coding to be used for recording military incidents involving the basic elements of personnel, materiel, and environment. These basic elements are subdivided into appropriate categories related to organization, function, process, etc. In all, 19 distinct kinds of elements are encoded. The system is designed for application on IBM cards and Logistic Computer Tape. The bulk of the report consists of tabulations of specific coding units (derived from a study of World War II records), with brief textual explanations.



KEYWORDS: Coding; Handbooks; Military operations


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| 1. ORIGINATING ACTIVITY (Corporate author)<br>Purdue University, Engineering Experiment Station<br>Airphoto Interpretation Laboratory<br>West Lafayette, Indiana | 2a. REPORT SECURITY CLASSIFICATION<br>Unclassified<br>2b. GROUP |

3. REPORT TITLE

TERRAIN STUDY OF THE YUMA TEST STATION AREA

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
Contract Report

5. AUTHOR(S) (Last name, first name, initial)
Frost, Robert E.; Johnston, James G.; Lindsey, Alton A., Miles, Robert D.; Shepard, James R.

| 6. REPORT DATE | 7a. TOTAL NO. OF PAGES | 7b. NO. OF REFS |
|---|---|---|
| March 1955 | 184 | 28 |

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| 8a. CONTRACT OR GRANT NO.<br>DA 22-079-eng-134<br>b. PROJECT NO.<br>DA No. 8-97-10-004<br>c.<br>d. | 9a. ORIGINATOR'S REPORT NUMBER(S)<br><br>9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)<br>WES Contract Report 3-14 (AD 626 500) |

10. AVAILABILITY/LIMITATION NOTICES

Approved for public release; distribution unlimited.

| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY |
|---|---|
| | U. S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi |

13. ABSTRACT The terrain and environmental features of the Yuma Test Station Area are the subject of this study. This area in western Arizona and southeastern California from Yuma to Death Valley is the hottest and driest part of the United States.

Twenty-six per cent of the Yuma Test Station Area consists of mountains, most of which are rugged and difficult to traverse. Hills comprise 17 percent of the Test Station Area. The terrain is rolling to rough, although local elevation differences are usually not great.

Plains make up fifty-seven percent of the Test Station Area and provide the most suitable locations for most of the various activities that are being conducted at the Test Station. Forty-four percent of the total area is alluvial aprons. Much of the surface consists of desert pavement, a firm mosaic of pebbles that has formed on exposed rock surfaces, both pebbles and bedrock. Except on the flood-plains and along the washes, vegetation is very sparse in the area.

In the opinion of most of the personnel of the test teams that were interviewed, environmental conditions at the Yuma Test Station offer conditions that are suitable for conducting most of the desert testing programs. Illustrations, tables, maps. One appendix.

KEYWORDS: Desert regions; Military bases; Terrain analysis; [Yuma, Arizona]

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|---|---|
| 1. ORIGINATING ACTIVITY (Corporate author)<br>Cornell University<br>School of Civil Engineering<br>Ithaca, New York | 2a. REPORT SECURITY CLASSIFICATION<br>Unclassified<br>2b. GROUP |

3. REPORT TITLE
AN ENVIRONMENTAL ANALYSIS OF THE FORT CHURCHILL, MANITOBA REGION, VOLS. I AND II, FOLIO

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
Contract Report

5. AUTHOR(S) (Last name, first name, initial)
Cheney, Theodore A.; Beckel, D. K. Brown

| 6. REPORT DATE | 7a. TOTAL NO. OF PAGES | 7b. NO. OF REFS |
|---|---|---|
| 30 May 1955 | Vol. I, 215; Vol. II, 168 | 53 |

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10. AVAILABILITY/LIMITATION NOTICES
Approved for public release; distribution unlimited.

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| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY<br>WES |

13. ABSTRACT This report is introduced with a general description of the cultural and natural features of the Fort Churchill environment. In the detailed discussions of the natural features, the area is described according to changes in climate and terrain with season. The summer and fall terrain is classified according to drainage, vegetation, and military characteristics. The winter and spring terrain is divided into two main categories; wooded and nonwooded, because of differences in type and accumulation of snow. General considerations of the Fort Churchill environment are dealt with according to problems in trafficability, navigation, and site selection. Illustrations, tables, maps, 6 appendices.

KEYWORDS: Environmental analysis; Environmental factors; Subarctic regions; Trafficability; [Fort Churchill, Canada]

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Security Classification

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| 1. ORIGINATING ACTIVITY (Corporate author)<br>North Carolina State College<br>School of Engineering<br>Raleigh, North Carolina | 2a. REPORT SECURITY CLASSIFICATION<br>Unclassified<br>2b. GROUP |

3. REPORT TITLE
TERRAIN STUDY OF THE PANAMA CANAL ZONE WITH SPECIFIC REFERENCE TO THE FORT SHERMAN AREA AND VICINITY

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
Contract Report

5. AUTHOR(S) (Last name, first name, initial)
McCullogh, C. R.
Johnston, I. M.
Parker, J. M., Jr.

| 6. REPORT DATE | 7a. TOTAL NO. OF PAGES | 7b. NO. OF REFS |
|---|---|---|
| July 1956 | 279 | 43 |

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| 8a. CONTRACT OR GRANT NO.<br>DA 22-079-eng-178<br>b. PROJECT NO. | 9a. ORIGINATOR'S REPORT NUMBER(S) |
| c.<br>d. | 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)<br>WES Contract Report 3-18 |

10. AVAILABILITY/LIMITATION NOTICES
Approved for public release; distribution unlimited.

| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY |
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13. ABSTRACT Data were obtained on the physical features of the Panama Canal Zone both by library search and field investigations. Reconnaissance was conducted throughout the Zone; the area of Ft. Sherman and vicinity on the Atlantic side of the Isthmus constituted the principal study area. This region contains the largest number of significantly different type areas that impose different military operational requirements. Seventeen test stations were established in the principal study area and one station in a savanna type area on the Pacific side. Detailed studies were made of vegetation characteristics, soils were sampled and tested, and geologic features were examined. Illustrations, tables, maps; two appendices.

KEYWORDS: Military bases; Terrain analysis; Tropical regions; [Ft. Sherman, C. Z.; Panama Canal Zone]

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1. ORIGINATING ACTIVITY (Corporate author)
Purdue University
Engineering Experiment Station
Lafayette, Indiana

2a. REPORT SECURITY CLASSIFICATION
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2b. GROUP

3. REPORT TITLE
TECHNIQUES FOR PREDICTING SOIL TRAFFICABILITY INFORMATION FROM AERIAL PHOTOGRAPHS

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

5. AUTHOR(S) (First name, middle initial, last name)
Robert D. Miles

6. REPORT DATE: September 1956

7a. TOTAL NO. OF PAGES: 207

7b. NO. OF REFS: 47

8a. CONTRACT OR GRANT NO. DA-079-eng-59

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9a. ORIGINATOR'S REPORT NUMBER(S)

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10. DISTRIBUTION STATEMENT
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11. SUPPLEMENTARY NOTES

12. SPONSORING MILITARY ACTIVITY
U. S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi

13. ABSTRACT
This study is part of a comprehensive program of research devoted to further knowledge concerning the estimation of quantitative soil trafficability information by remote means, particularly through the correlation and analysis of aerial photographic patterns. The report discusses previous investigations in this field and factors that influence soil trafficability. Techniques are presented for photo interpretation of soils and landform elements; the effects of season and scale in inferring trafficability information are described. A two-year study was undertaken at three test areas in Indiana to test the validity of the techniques. Photo tones and texture were correlated with soil moisture and ground conditions.

KEYWORDS: Airphoto interpretation; Terrain analysis; Trafficability prediction; [Indiana]

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| 1. ORIGINATING ACTIVITY (Corporate author)<br>U. S. Geological Survey, Military Geology Branch<br>Department of the Interior<br>Washington, D. C. | 2a. REPORT SECURITY CLASSIFICATION<br>Unclassified<br>2b. GROUP |

3. REPORT TITLE

TERRAIN STUDY OF THE ARMY TEST AREA, FORT GREELY, ALASKA

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Contract Report

5. AUTHOR(S) (Last name, first name, initial)

Holmes, G. William; Benninghof, William S.

| 6. REPORT DATE | 7a. TOTAL NO. OF PAGES | 7b. NO. OF REFS |
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| 1957 | 287 | 22 |

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| 8a. CONTRACT OR GRANT NO.<br>b. PROJECT NO.<br>8-97-10-004<br>c.<br>d. | 9a. ORIGINATOR'S REPORT NUMBER(S)<br>9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)<br>WES Contract Report No. 3-22, Vols 1-2 |

10. AVAILABILITY/LIMITATION NOTICES

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| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY |
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13. ABSTRACT This report discusses environmental elements found at Fort Greely, Alaska that are both stable and variable with respect to seasonal change. The stable elements treated are topography, landforms, geology, soils, permafrost, and ground water. Elements exhibiting marked seasonal variations are wind action, soil moisture and temperature, vegetation, snow, lakes and streams. Some discussion is made of the testing and training activities at Fort Greely. The environmental factors found in the test area are evaluated for the important stable and seasonal elements, for elements common to the subarctic, for major factors which make the test area distinctive, for terrain factors represented in the test area and for the feasibility of cross-country movement. Illustrations, tables, maps

KEYWORDS: Environmental analysis; Military bases; Subarctic regions; Trafficability; [Fort Greely, Alaska]

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|---|---|
| 1. ORIGINATING ACTIVITY (Corporate author)<br>Vanderbilt University<br>Dept. of Civil Engineering<br>Nashville 5, Tenn. | 2a. REPORT SECURITY CLASSIFICATION<br>Unclassified<br>2b. GROUP |

3. REPORT TITLE

THE DESCRIPTION AND CLASSIFICATION OF HYDROLOGIC CHARACTERISTICS FOR MILITARY PURPOSES

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Contract Report

5. AUTHOR(S) (Last name, first name, initial)

Krenkel, Peter A.; Hoadley, Peter G.; Carpenter, John A.

| 6. REPORT DATE | 7a. TOTAL NO. OF PAGES | 7b. NO. OF REFS |
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| 1 July 1964 | 100 | 7 |

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10. AVAILABILITY/LIMITATION NOTICES

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| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY<br>WES |

13. ABSTRACT

An expression defining the stage-cumulative frequency function for the Bellview gage on the Harpeth River is developed and discussed. Three methods of stage-bank slope analysis are described and their relationship shown. Mathematical models of bank sections are equated and compared.

Tables and graphs.

KEYWORDS: Hydrologic geometry; Hydrologic geometry classification; Mathematical models; Military operations; Surface water

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| 1. ORIGINATING ACTIVITY (Corporate author)<br>Vanderbilt University<br>Dept. of Civil Engineering<br>Nashville 5, Tenn. | | 2a. REPORT SECURITY CLASSIFICATION<br>Unclassified<br>2b. GROUP |
| 3. REPORT TITLE<br>THE DESCRIPTION AND CLASSIFICATION OF HYDROLOGIC CHARACTERISTICS FOR MILITARY PURPOSES | | |
| 4. DESCRIPTIVE NOTES (Type of report and inclusive dates)<br>Contract Report | | |
| 5. AUTHOR(S) (Last name, first name, initial)<br>Krenkel, Peter A.; Carpenter, John A.; Chen, P. C. | | |
| 6. REPORT DATE<br>30 December 1964 | 7a. TOTAL NO. OF PAGES<br>85 | 7b. NO. OF REFS |
| 8a. CONTRACT OR GRANT NO.<br>DA-22-079-eng-360<br>b. PROJECT NO.<br>c.<br>d. | 9a. ORIGINATOR'S REPORT NUMBER(S)<br>9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)<br>WES Contract Report 3-23, Supplement | |
| 10. AVAILABILITY/LIMITATION NOTICES<br>Approved for public release; distribution unlimited. | | |
| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY<br>WES | |

13. ABSTRACT

This report should be considered as a supplement to the report entitled, "The Description and Classification of Hydrologic Characteristics for Military Purposes," 1 July 64, by Vanderbilt University. The relationship between stage and cumulative frequency of stage occurrence was reanalyzed in view of a slight error in data conversion and the addition of data from other gaging stations. A procedure was developed to reconstruct the curves of stage-percent occurrence where coefficients a, b, and c are a parabolic function. A modified procedure for reconstructing a channel cross section was devised. The equation is a fifth degree polynomial in terms of certain bank shape parameters.

Tables, graphs.

KEYWORDS: Hydrologic geometry; Hydrologic geometry classification; Mathematical models; Military operations; Surface water

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| 1. ORIGINATING ACTIVITY (Corporate author)<br>George Washington University<br>Washington, D. C. | 2a. REPORT SECURITY CLASSIFICATION<br>Unclassified<br>2b. GROUP |

3. REPORT TITLE

HISTORICAL RECORDS PROJECT--FINAL REPORT: SECTION I, INTRODUCTION, EVALUATION, AND RECOMMENDATIONS

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Contract Report

5. AUTHOR(S) (Last name, first name, initial)

Campbell, Robert D.

| 6. REPORT DATE | 7a. TOTAL NO. OF PAGES | 7b. NO. OF REFS |
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| 15 September 1957 | 12 | |

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| 8a. CONTRACT OR GRANT NO.<br>DA-22-079-eng-194<br>b. PROJECT NO.<br>DA-8-97-10-001<br>c. DA-8-97-10-002<br>d. | 9a. ORIGINATOR'S REPORT NUMBER(S)<br><br>9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)<br>WES Contract Report 3-24, Section 1 |

10. AVAILABILITY/LIMITATION NOTICES

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| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY |
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| | WES |

13. ABSTRACT

"The primary purposes of the overall study are to determine what environmental factors, or complexes of factors, influenced military operations in the areas studied, and to develop the best available evaluation of the magnitude of such effects..." The approach to the study consisted of a survey and analysis of historical records. The results of the study are reported in eight sections, separately bound, of which this is the first section.

Maps, tables

KEYWORDS: Environmental factors; Historical records; Military operations

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| 1. ORIGINATING ACTIVITY (Corporate author) George Washington University Washington, D. C. | 2a. REPORT SECURITY CLASSIFICATION Unclassified |
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3. REPORT TITLE
HISTORICAL RECORDS PROJECT
FINAL REPORT: SECTION 2, THE ENVIRONMENTAL ELEMENT IN MILITARY OPERATIONS

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
Contract Report

5. AUTHOR(S) (Last name, first name, initial)
Campbell, Robert D.

| 6. REPORT DATE | 7a. TOTAL NO. OF PAGES | 7b. NO. OF REFS |
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| b. PROJECT NO. DA 8-97-10-001 | |
| c. DA 8-97-10-002 | 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) |
| d. | WES Contract Report 3-24, Section 2 |

10. AVAILABILITY/LIMITATION NOTICES
Approved for public release; distribution unlimited.

| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY |
|---|---|
| | WES |

13. ABSTRACT
This report constitutes the second of eight sections, bound separately, of the final report of the Historical Records Project. Some 9200 reported incidents of environmental impact were analyzed to relate elements (mud, fog, underbrush, etc.) to their effects on operations.

Maps, tables

KEYWORDS: Environmental factors; Historical records; Military operations

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| 1. ORIGINATING ACTIVITY (Corporate author)<br>George Washington University<br>Washington, D. C. | 2a. REPORT SECURITY CLASSIFICATION<br>Unclassified<br>2b. GROUP |

3. REPORT TITLE

HISTORICAL RECORDS PROJECT
FINAL REPORT: SECTION 3, MILITARY OPERATIONS AS CHARACTERIZED BY THE EFFECTS OF ENVIRONMENT

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Contract Report

5. AUTHOR(S) (Last name, first name, initial)

Hesaltine, Charles E., Jr.

| 6. REPORT DATE | 7a. TOTAL NO. OF PAGES | 7b. NO. OF REFS |
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| 8a. CONTRACT OR GRANT NO.<br>DA 22-079-eng-194<br>b. PROJECT NO.<br>DA 8-97-10-001<br>c. DA 8-97-10-002<br>d. | 9a. ORIGINATOR'S REPORT NUMBER(S)<br><br>9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)<br>WES Contract Report 3-24, Section 3 |

10. AVAILABILITY/LIMITATION NOTICES

Approved for public release; distribution unlimited.

| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY |
|---|---|
| | WES |

13. ABSTRACT

This is section three of a report in eight sections, bound separately. The data collected by the Historical Records Project are in the form of "incidents" of environmental impact, taken from the military documents of the campaigns of the North African, Mediterranean, and European theaters, and of the Korean conflict. The records were excerpted on IBM cards, and coded according to a numerical system of classification which associates the kinds of activities with the impact of the environments. The distribution of environmental effects is a function of the type of operation, and distribution of effects varies from one location to another. The relative distribution of effects varies with season.

Tables, graphs. One appendix

KEYWORDS: Environmental factors; Historical records; Military operations

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George Washington University
Washington, D. C.

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4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
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5. AUTHOR(S) (Last name, first name, initial)
Mason, Randolph N., Jr.

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11. SUPPLEMENTARY NOTES

12. SPONSORING MILITARY ACTIVITY
WES

13. ABSTRACT

This is the fourth of eight sections, bound separately. This section presents an attempt to develop a method whereby a military leader in the field can estimate the probable impact of environment on his specific planned operation. It is based upon analyses of the relationships of environmental elements, military operations, and accomplishment of operation. "The association of environmental elements and military operations in terms of environmental impact can be used for predictive purposes within the statistical limits described."

Graphs, charts, tables. One appendix

KEYWORDS: Environmental factors; Historical records; Military operations

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3. REPORT TITLE

HISTORICAL RECORDS PROJECT
FINAL REPORT: SECTION 5, THE NINE-COORDINATE PROBABILITY MODEL DESCRIBING ENVIRONMENT-MILITARY OPERATIONS RELATIONSHIPS

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Contract Report

5. AUTHOR(S) (Last name, first name, initial)

McCall, Chester H., Jr.

| 6. REPORT DATE | 7a. TOTAL NO. OF PAGES | 7b. NO. OF REFS |
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10. AVAILABILITY/LIMITATION NOTICES

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| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY |
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13. ABSTRACT

A model is here defined as a mathematical system which indicates relationships existing among a set of variables which are representative of some quantitative or qualitative classification. Of the fifteen categories of the classification and coding system developed under this project (described in the previous sections), nine are utilized in the empirical model described in this section (a mathematical model is described in a subsequent section). These are: time, location, operation, functional classes of materiel and personnel, environmental effects on materiel and personnel, elements of the environment, military organization, magnitude of effect, and accomplishment (outcome) of the operation. These are thought to represent the fundamental core of relationships. With these, a nine-coordinate statistical model is developed, which "can be used as a predictive device for future military operations and also as a means of defining military operations and studying the impact of the environment on these operations.

Three appendices

KEYWORDS: Environmental factors; Historical records; Military operations; Statistical analysis

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| 1. ORIGINATING ACTIVITY (Corporate author) George Washington University Washington, D. C. | 2a. REPORT SECURITY CLASSIFICATION Unclassified |
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3. REPORT TITLE

HISTORICAL RECORDS PROJECT
FINAL REPORT: SECTION 6, THE MILITARY REGION: A MATHEMATICAL MODEL

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

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5. AUTHOR(S) (Last name, first name, initial)

Heller, Isidor

| 6. REPORT DATE | 7a. TOTAL NO. OF PAGES | 7b. NO. OF REFS |
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| 8a. CONTRACT OR GRANT NO. DA 22-079-eng-194 | 9a. ORIGINATOR'S REPORT NUMBER(S) |
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10. AVAILABILITY/LIMITATION NOTICES

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| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY |
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| | WES |

13. ABSTRACT

This paper develops "a mathematical model relating environmental effects (on operations, on personnel, and on materiel) to environmental elements; and a method for testing the model." It is specifically qualified that the only relationships of interest are cause-effect relationships, and these only when directed from environment to operations, materiel, personnel, etc. Three assumptions are necessary: (1) it is possible to measure the environmental elements (they are in fact numbered); (2) the effects can be measured (in degrees of "does" or "does not" occur; (3) for any measure chosen for the effect, there exists a measure for environmental elements such that effect is related to environment in a linear fashion, i.e. effects are additive. Elements and effects are translated into vectors in euclidean space. "The assumption that the effect vector Y is related to the environment vector X in a linear fashion means that there exists a matrix A such that for any environment vector X the associated effect vector Y is determined by the relation Y = AX. This basic model is expanded for "combined operations." The limitations and applications of the model are discussed (for the former the author can foresee but very few).

KEYWORDS: Environmental factors; Historical records; Mathematical models; Military operations

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3. REPORT TITLE

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FINAL REPORT: SECTION 7, EVALUATION OF THE FACTOR ANALYSIS IN A STUDY OF THE EFFECTS OF ENVIRONMENT ON MILITARY OPERATIONS

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Contract Report

5. AUTHOR(S) (Last name, first name, initial)

McCall, Chester H., Jr.

| 6. REPORT DATE | 7a. TOTAL NO. OF PAGES | 7b. NO. OF REFS |
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10. AVAILABILITY/LIMITATION NOTICES

Approved for public release; distribution unlimited.

| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY |
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| | WES |


13. ABSTRACT During the course of the studies in the Historical Records Project, it became apparent that a need existed for some concrete mathematical and statistical method for examining the multitude of matrices which were emanating from this study. The existing literature on factor analysis involves, primarily, the examination of square, symmetric matrices. In the Historical Records Project, the matrices are neither square nor symmetrical, and it is necessary therefore to develop a method for examining matrices not possessing these two desirable properties. A technique developed by Dr. Max Woodbury is applied to six of the project's matrices (environmental effects on material x major locations, 12x10; environmental elements x operations, 72x20; etc.). This paper includes a mathematical and statistical justification of the process, and the need for additional research is discussed.



KEYWORDS: Environmental factors; Historical records; Mathematical models; Military operations; Statistical analysis


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| 3. REPORT TITLE HISTORICAL RECORDS PROJECT FINAL REPORT: SECTION 8, DELINEATION OF THE MILITARY REGION | | |
| 4. DESCRIPTIVE NOTES (Type of report and inclusive dates) Contract Report | | |
| 5. AUTHOR(S) (Last name, first name, initial) Campbell, Robert D. | | |
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| 10. AVAILABILITY/LIMITATION NOTICES Approved for public release; distribution unlimited. | | |
| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY WES | |

13. ABSTRACT


A "military region" is a region within which a given operation will be affected differently than will the same operation in an adjacent region. The Historical Records Project has revealed that locations definitely vary in their military characteristics, and therefore military regions are theoretically mappable. Nonetheless, it is possible only to suggest the methods for delineating a military region; it is not possible actually to delineate such regions because of two inadequacies in the data: there are not sufficient cases of environmental impact for a detailed study; the environment was rarely "measured." Military regions should be delineated in terms of specific operations, and only the elements with high "impact ratings" should be used for a specific operation.

One appendix



KEYWORDS: Environmental factors, Historical records; Military operations


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| 1. ORIGINATING ACTIVITY (Corporate author) U. S. Geological Survey, Military Geology Branch Dept. of the Interior Washington, D. C. | 2a. REPORT SECURITY CLASSIFICATION Unclassified<br>2b. GROUP |
| 3. REPORT TITLE TECHNIQUES FOR DETERMINATION OF TERRAIN ANALOGS | |
| 4. DESCRIPTIVE NOTES (Type of report and inclusive dates) Contract Report | |
| 5. AUTHOR(S) (Last name, first name, initial) Stoertz, George E. | |
| 6. REPORT DATE November 1957 | 7a. TOTAL NO. OF PAGES 78 / 7b. NO. OF REFS 38 |
| 8a. CONTRACT OR GRANT NO.<br>b. PROJECT NO. 8-97-10-004<br>c.<br>d. | 9a. ORIGINATOR'S REPORT NUMBER(S)<br>9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) WES Contract Report 3-25, AD 716 975 |
| 10. AVAILABILITY/LIMITATION NOTICES Approved for public release; distribution unlimited. | |
| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY WES |

13. ABSTRACT The objective of a terrain analog technique is to enable the comparison of geographic areas on the basis of those aspects of the terrain which are most significant for military operations. The following basic techniques are described in this report; prevalence of restrictive values of selected terrain factors; suitability for military activities; landform classification, based on local relief and/or slope; total range of values of selected terrain factors. Alternative techniques are evaluated from the standpoints of: purpose of comparison; quantitative versus qualitative approach; degree of detail of the analog technique; consideration of seasonal variations of terrain; methods of presentation adaptable to the analog technique; flexibility of the analog technique to meet changing military requirements and changing equipment characteristics; simplicity of the analog technique, or the relative ease of determination of analogs by the compiler compared with ease of interpretation by the user; validity of the analog technique.

The proposed technique for determination of terrain analogs consists first of the identification of broadly similar areas on the basis of major landforms, and then the identification of closely analogous areas on the basis of critical or restrictive values of selected terrain factors.

A frequency rating, on a numerical scale from 0 to 9, is proposed as a method for representing the prevalence of terrain conditions on a common basis.

Eighteen selected terrain factors are discussed in this report, and significant scale ranges or critical values are proposed for each.

KEYWORDS: Military operations; Terrain analogs; Terrain classification; Terrain factors

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| 1. ORIGINATING ACTIVITY (Corporate author) Headquarters, Quartermaster Research and Engineering Command, U. S. Army Natick, Mass. | 2a. REPORT SECURITY CLASSIFICATION Unclassified |
| | 2b. GROUP |

3. REPORT TITLE

CLIMATIC ANALOGS OF FORT GREELY, ALASKA AND FORT CHURCHILL, CANADA, IN EURASIA

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

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5. AUTHOR(S) (First name, middle initial, last name)

Falkowski, Sigmund J.

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| c. | 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) |
| d. | WES Contract Report 3-27(1) |

10. DISTRIBUTION STATEMENT

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| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY |
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| Environmental Analogs Project | WES |

13. ABSTRACT

Climatic conditions at Fort Greely, Alaska, and Fort Churchill, Canada, are compared with the climates of arctic and subarctic regions in Eurasia. The climatic elements are treated in the discussion, and maps are included to present pictorially the distribution of analogous conditions.

The cold region around the "cold pole" of Siberia, in the vicinity of Verkhoyansk, is too cold for analogy to either test site. Mean temperatures for the coldest month are analogous to those of Fort Churchill in a relatively narrow band encircling this region. Coldest month temperatures analogous to those of Fort Greely, the warmer of the two test sites, are found in a second, outer band around the Siberian core region of extreme cold.

Only very limited areas areas are found where both temperature and windchill conditions are analogous. Areas analogous to Novaya Zemlya and to the coastal areas bordering the southern part of the Kara Sea. Windchill and temperature conditions analogous to those of Fort Churchill during the coldest month are best defined in the northern lowlands between the Ob and Yenisey Rivers and along the Arctic coast from the Yenisey to the Lena River.

Combined summer-winter temperatures and annual precipitation analogy to Fort Greely exists only in the northern part of the Central Russian Tableland and adjoining parts of the West Siberian Lowland. The northern part of the West Siberian lowland and the Arctic Lowlands to the north receive annual precipitation amounts and have summer-winter temperatures analogous to those at Fort Churchill. Larger areas are indicated where annual precipitation combined with either summer or winter temperatures is analogous to the test sites. Maps, tables Arctic regions, climate

KEYWORDS: Climatic analogs; Climatology; Military bases; Subarctic regions; [Alaska; Fort Churchill, Canada]

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Headquarters, Quartermaster Research and Engineering Command, U. S. Army
Natick, Mass.

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4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
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5. AUTHOR(S) (First name, middle initial, last name)
Hastings, Andrew D., Jr.

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11. SUPPLEMENTARY NOTES
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12. SPONSORING MILITARY ACTIVITY
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13. ABSTRACT

Twelve climatic elements are mapped and analogous areas are indicated. Ranges of analogy vary with the element being measured, but for most elements the southern limit of close analogy for both test sites lies north of the 45° parallel (roughly the northern tier of states in the United States). Areas of analogy are designated on the maps by yellow areas for Fort Greely and blue areas for Fort Churchill. Except for absolute minimum temperature, Fort Churchill has the colder environment of the two sites; hence the more northerly zone of cold analogy shown is usually that of Fort Churchill. Areas of analogy for both test sites tend to extend farthest southward over midcontinent regions.

Composite areas of analogy for multiple elements are also mapped. Areas analogous to Fort Churchill for combined coldest month temperatures, snow depth, and windchill are found primarily in the Hudson Bay Lowland. For Fort Greely, analogous areas for the above combination of elements are confined to the immediate vicinity of Fort Greely, northwestern Alaska, southern Manitoba, and small areas on the coast of Greenland.

Areas of composite analogy with Fort Greely for winter and summer temperature and mean annual precipitation occur in the Tanana Valley of Alaska, southern Yukon Territory, and in small scattered areas of western Alaska. Fort Churchill analogy for the same combination of elements occurs in a 500-mile-wide salient stretching westward from Hudson Bay and a smaller patch in interior northern Quebec.

KEYWORDS: Climatic analogs; Climatology; Military bases; Subarctic regions; [Fort Churchill, Canada; Fort Greely, Alaska]

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3. REPORT TITLE
CANAL ZONE ANALOGS NO. I
ANALOGS OF CANAL ZONE CLIMATE IN MIDDLE AMERICA

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
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5. AUTHOR(S) (Last name, first name, initial)
Chambers, Jack V.
Blout, James M.

| 6. REPORT DATE | 7a. TOTAL NO. OF PAGES | 7b. NO. OF REFS |
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| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY |
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| Project Reference 7-83-01-005A | WES |


13. ABSTRACT This study compares the climate of Middle America with that of two locations in the Canal Zone: Balboa Heights, representing the drier leeward Pacific side of the Isthmus of Panama, and Cristobal, representing the wetter windward Atlantic side. Distribution of areas of analogy of pertinent climatic elements and combinations is shown in maps. The areas of close climatic analogy of combinations of climatic elements (temperature and precipitation) to the Canal Zone are generally small; even the largest area of composite analogy with Cristobal includes only the Atlantic coastal lowlands from Bluefields, Nicaragua to the Panama - Colombia border. Some individual climatic elements, however, show extensive analogy; the area with summer temperatures analogous to those of Cristobal extends throughout nearly all of Middle America and much of the United States. North of latitude 18°N and in highland areas, temperatures for the coldest month are much lower than those of either Balboa Heights or Cristobal.

Annual rainfall is closely analogous to that of Balboa Heights in part of the Gulf Coast of southeastern United States, and in southern Mexico, Central America, and the Caribbean Islands. Areas as wet as Cristobal are smaller. The wettest areas are also the cloudiest.
Maps, Tables.



KEYWORDS: Climatic analogs; Climatology; Tropical regions; [Central America; Panama; West Indies]


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3. REPORT TITLE
CANAL ZONE ANALOGS NO. II
ANALOGS OF CANAL ZONE CLIMATE IN INDIA AND SOUTHEAST ASIA

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
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5. AUTHOR(S) (Last name, first name, initial)
Thompson, Will F.

| 6. REPORT DATE | 7a. TOTAL NO. OF PAGES | 7b. NO. OF REFS |
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| 8a. CONTRACT OR GRANT NO. | 9a. ORIGINATOR'S REPORT NUMBER(S) |
| b. PROJECT NO. 8-97-10-004 | Technical Report EP-91 |
| c. | 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) |
| d. | WES Contract Report 3-30, No. II |

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| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY |
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| Project Reference 7-83-01-005 | WES |

13. ABSTRACT India and Southeast Asia are more variable in temperature and more seasonal in precipitation than the Canal Zone. North of 20° N latitude in the coldest month all stations are cooler than those in the Canal Zone. This is also true of most stations between 15° and 20° N. South of 15° N, large lowland areas are analogous for mean temperature of the coldest month. Except where special conditions prevail (cloudy Bengal, the eastern piedmont of the Himalayas, and the Arabian Sea coast), lowland stations north of 15° N are too warm for analogy in the warmest month, which is usually May, just before the rainy season. Temperatures are more moderate with the onset of the summer monsoon later in the year.

Nearly all of the area is analogous for precipitation amounts in the wettest month and during most of the summer monsoon season. Relative humidity is low in the driest month over most of the area, and high during the rainy season. Analogy for windiness and cloudiness of the wettest month is extensive. Because temperatures are moderate during the summer monsoon, multiple analogy with the Canal Zone is extensive at that time.

Year-round multiple analogy is limited to the southern part of the area. Areas of such analogy with Balboa Heights (on the Pacific side of the Canal Zone) which has well-marked seasons, are Ceylon, southernmost India, Malaya, Laos, South Viet Nam, and Cambodia. Year-round composite analogy to Cristobal occurs only in Malaya. Areas of analogy are given in 14 maps; the last 2 maps show the distribution of multiple analogy. Maps, tables

KEYWORDS: Climatic analogs; Climatology; Tropical regions; [Asia (Southeast); India; Panama, C. Z.]

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| 1. ORIGINATING ACTIVITY (Corporate author)<br>Headquarter Quartermaster Research and Engineering Command, U. S. Army<br>Natick, Mass | 2a. REPORT SECURITY CLASSIFICATION<br>Unclassified<br><br>2b. GROUP |

3. REPORT TITLE

CANAL ZONE ANALOGS NO. III
ANALOGS OF CANAL ZONE CLIMATE IN EAST CENTRAL AFRICA

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

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5. AUTHOR(S) (Last name, first name, initial)

Blair, Walter B.

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13. ABSTRACT

The climate of East Central Africa is compared with that of Balboa Heights and Cristobal in the Canal Zone. Distributions of areas of analogy of pertinent climatic elements and combinations of these elements are shown on maps. Most of the study area is too hot and too dry for analogy with the tropical environment of the Canal Zone. No part of the study area has enough rainfall to be comparable with Cristobal. The one area that is closely analogous to Balboa Heights is in the Congo Basin, west of longitude 30° E and south of latitude 70°N. The amount of rainfall analogous to that of Balboa Heights is limited mostly to the southwestern part of the study area. Highlands in Kenya, Uganda, and Ethiopia are the only areas which are too cool for analogy with either Canal Zone station.

Relative humidities in most of the desert and interior regions are too low for analogy. However, some areas near the Gulf of Aden, Indian Ocean, Lake Victoria, and the Congo River, are either analogous or are too high for analogy. Areas with greatest mean monthly precipitation have mean cloudiness conditions nearly analogous to the Canal Zone. Analogy of mean wind speeds with those in the Canal Zone is erratically scattered throughout East Central Africa.
Maps, tables



KEYWORDS: Climatic analogs; Climatology; Tropical regions;[Africa (Central); Panama, C. Z.]


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**1. ORIGINATING ACTIVITY (Corporate author)**
Headquarters, Quartermaster Research and Engineering Command, U. S. Army
Natick, Mass.

**2a. REPORT SECURITY CLASSIFICATION**
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**3. REPORT TITLE**
CANAL ZONE ANALOGS NO. IV
ANALOGS OF CANAL ZONE CLIMATE IN WEST CENTRAL AFRICA

**4. DESCRIPTIVE NOTES (Type of report and inclusive dates)**
Contract Reports

**5. AUTHOR(S) (Last name, first name, initial)**
Thompson, Will F.

| 6. REPORT DATE | 7a. TOTAL NO. OF PAGES | 7b. NO. OF REFS |
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**8a. CONTRACT OR GRANT NO.**

**b. PROJECT NO.** 8-97-10-004

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**9a. ORIGINATOR'S REPORT NUMBER(S)**
Technical Report EP-93

**9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)**
WES Contract Report 3-30, No. IV

**10. AVAILABILITY/LIMITATION NOTICES**
Approved for public release; distribution unlimited.

**11. SUPPLEMENTARY NOTES**
Project Reference 7-83-01-005A

**12. SPONSORING MILITARY ACTIVITY**
WES

**13. ABSTRACT** The results of climatic testing in the Canal Zone may be applied with considerable confidence to much of the northern shore of the Gulf of Guinea. The climate of the coast is closely analogous to that of either the Atlantic or Pacific side of the Canal Zone except for the western part of the Bight of Benin.

Close analogy to Cristobal, representing the wetter, windward, Atlantic side of the Canal Zone, is found in the wetter parts of the study area at the head of the Bight of Biafra and seaward of the Guinea Highlands. Close analogy to Balboa Heights, representing the drier, leeward, Pacific side of the Canal Zone, occurs on the east side of the Guinea Highlands, on the coast between the Guinea Highlands and the west side of the Bight of Benin, on the eastern shore of the Bight of Benin, on the upper Niger delta, and on the southern and eastern sides of the Cameroons-Gabon Plateau.

Analogy with the various single elements mapped in this study is generally coastal in distribution, extending north in some instances to cover the sudan. The Atlantic coast of the Sahara and certain Saharan uplands are analogous only for temperature of the warmest month; otherwise, the Sahara is not analogous.
Maps, tables

KEYWORDS: Climatic analogs; Climatology; Tropical regions; [Africa (West Central); Panama, C. Z.]

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Headquarters, Quartermaster Research and Engineering Command, U. S. Army
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**3. REPORT TITLE**
CANAL ZONE ANALOGS NO. V
ANALOGS OF CANAL ZONE CLIMATE IN SOUTH CENTRAL AFRICA AND MADAGASCAR

**4. DESCRIPTIVE NOTES (Type of report and inclusive dates)**
Contract Report

**5. AUTHOR(S) (Last name, first name, initial)**
Blair, Walter Beale

| 6. REPORT DATE | 7a. TOTAL NO. OF PAGES | 7b. NO. OF REFS |
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**8a. CONTRACT OR GRANT NO.**

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**9a. ORIGINATOR'S REPORT NUMBER(S)**
Technical Report EP-94

**9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)**
WES Contract Report 3-30, No. V

**10. AVAILABILITY/LIMITATION NOTICES**
Approved for public release; distribution unlimited.

**11. SUPPLEMENTARY NOTES**
Project Reference 7-83-01-005A

**12. SPONSORING MILITARY ACTIVITY**
WES


**13. ABSTRACT** The climate of South Central Africa and Madagascar is compared with that of two localities in the Canal Zone; Balboa Heights, representing the drier, leeward, Pacific side of the Isthmus of Panama, and Cristobal, representing the wetter, windward, Atlantic side. Distribution of areas of analogy of pertinent climatic elements and combinations of these elements are shown on maps. The only area in South Central Africa that is analogous to either of the Canal Zone stations is the outer periphery of the Congo Basin, north of 7° S latitude and westward to the Atlantic Ocean; it is analogous to Balboa Heights. This analogous area does not have as much rainfall as Cristobal. Some of the higher areas which are analogous to Balboa Heights in precipitation are too cold for temperature analogy. The area of analogy for the mean temperature of the warmest month is much larger than the area of analogy for the mean temperature of the coldest month. The study area has greater mean daily ranges of temperature than the Canal Zone. An area in the most continental and equatorial part of the Congo Basin is not analogous because of too many wet months. For mean cloudiness of the wettest month and relative humidity of the driest month, analogy appears to exist between the Canal Zone and much of the study area, but not enough data are available to draw firm conclusions.
Maps, tables



KEYWORDS: Climatic analogs; Climatology; Tropical regions; [Africa (Central); Madagascar; Panama C. Z.]


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3. REPORT TITLE

CANAL ZONE ANALOGS NO. VI
ANALOGS OF CANAL ZONE CLIMATE IN SOUTH AMERICA

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

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5. AUTHOR(S) (Last name, first name, initial)

Thompson, Will F.

| 6. REPORT DATE | 7a. TOTAL NO. OF PAGES | 7b. NO. OF REFS |
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| b. PROJECT NO. 8-97-10-004 | Technical Report EP-97 |
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| d. | WES Contract Report 3-30, No. VI |

10. AVAILABILITY/LIMITATION NOTICES

Approved for public release; distribution unlimited.

| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY |
|---|---|
| Project Reference: 7-83-01-005 | WES |


13. ABSTRACT Much of interior and eastern South America is climatically similar to the Canal Zone. Lowlands on the west coast north of Guayaquil are also similar, except that over considerable areas they have much more precipitation than any part of the Canal Zone. Highlands throughout the area mapped in this study are too cool for close analogy; subtropical areas in the southern part of the area are too cool in winter. The coast of Venezuela, the northern Brazilian Plateau, northwest Argentina, and the west coast south of Guayaquil are much too dry for climatic analogy with the Canal Zone.

Tropical lowlands considered analogous to Balboa Heights on the drier, Pacific side of the Canal Zone, have only moderately heavy precipitation and a well-marked dry season. Such areas are about twice as widespread in the study area as those analogous to Cristobal, the other Canal Zone station, which is on the wetter Atlantic side. Cristobal has heavy precipitation, though much less than the maximum amounts recorded in tropical South America, and has a brief dry season. Certain areas otherwise climatically similar to Cristobal fail of complete analogy because they have no dry season. For example, this is true of much of the northern part of the Amazon Basin.

Maps, tables.



KEYWORDS: Climatic analogs; Climatology; Tropical regions; [Panama C. Z.; South America]


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| 1. ORIGINATING ACTIVITY (Corporate author) | 2a. REPORT SECURITY CLASSIFICATION |
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| Headquarters, Quartermaster Research and Engineering Command, U. S. Army Natick, Mass. | Unclassified |
| | 2b. GROUP |

3. REPORT TITLE

CANAL ZONE ANALOGS NO. VII
ANALOGS OF CANAL ZONE CLIMATE IN INDONESIA, THE PHILIPPINES, AND BORNEO

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Contract Reports

5. AUTHOR(S) (Last name, first name, initial)

Thompson, Will F.

| 6. REPORT DATE | 7a. TOTAL NO. OF PAGES | 7b. NO. OF REFS |
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| b. PROJECT NO. 8-97-10-004 | Technical Report EP-116 |
| c. | 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) |
| d. | WES Contract Report 3-30, No. VII |

10. AVAILABILITY/LIMITATION NOTICES

Approved for public release; distribution unlimited

| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY |
|---|---|
| Project Reference: 7-83-01-005 | WES |

13. ABSTRACT

The climate of Indonesia, the Philippines, and Borneo is compared with that of two localities in the Canal Zone: Balboa Heights, representing the drier, leeward, Pacific side of the Isthmus of Panama, and Cristobal, representing the wetter, windward, Atlantic side. Distribution of areas of analogy of pertinent climatic elements and combinations of these elements are shown on maps.

Regional temperature differences are insignificant within Indonesia, the Philippines, and Borneo. Areas at low and moderate altitudes are consistently analogous with the Canal Zone stations; those areas at higher altitudes are consistently too cool for analogy.

Precipitation differences are more marked. The larger land areas of the mid-tropical East Indies (Borneo, Malaya, and Sumatra) are wetter than the rest of the study area. Analogy with Cristobal with respect to mean annual precipitation is widespread in those areas. However, the areas are not analogous with respect to number of wet months because much of the area has no dry season. Islands not on the Equator and the smaller, equatorial islands east of Borneo show pronounced precipitation seasonality and have numerous areas analogous to the Canal Zone, due to local differences in exposure to monsoon winds which blow alternately from Asia and Australia.

Maps, tables

KEYWORDS: Climatic analogs; Climatology; Tropical regions; [Borneo; Indonesia; Malaya; Panama C. Z.; Philippine Islands]

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1. ORIGINATING ACTIVITY (Corporate author)
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2a. REPORT SECURITY CLASSIFICATION
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3. REPORT TITLE
CANAL ZONE ANALOGS NO. VIII
ANALOGS OF CANAL ZONE CLIMATE IN AUSTRALIA AND NEW GUINEA

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
Contract Reports

5. AUTHOR(S) (Last name, first name, initial)
Blair, Walter B.
Chambers, Jack V.

| 6. REPORT DATE | 7a. TOTAL NO. OF PAGES | 7b. NO. OF REFS |
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9a. ORIGINATOR'S REPORT NUMBER(S)
Technical Report EP-113

9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)
WES Contract Report 3-30, No. VIII

10. AVAILABILITY/LIMITATION NOTICES
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11. SUPPLEMENTARY NOTES
Project Reference: 7-83-01-006

12. SPONSORING MILITARY ACTIVITY
WES

13. ABSTRACT

The climate of Australia and New Guinea is compared with that of two locations in the Canal Zone: Balboa Heights, representing the drier, leeward, Pacific side of the Isthmus of Panama, and Cristobal, representing the wetter, windward, Atlantic side. Areas of analogy of pertinent climatic elements and combinations of these elements are shown on maps.

Areas of complete climatic analogy to each Canal Zone station are found in certain portions of the lowlands of New Guinea. Climates in Australia are not analogous with either Canal Zone station but some climatic elements, such as mean temperature of the warmest month, are comparable. Areas below 2,000 feet in elevation either have analogy with Balboa Heights or Cristobal, or have wetter or hotter climates than these stations. Most of New Britain and the southern interior lowlands of New Guinea from the Gulf of Papua to the Arafura Sea, are high rainfall areas, usually receiving over 200 inches per year; this is much more than either Canal Zone station and therefore not analogous. The mountainous areas in New Guinea and in the neighboring islands are too cool for analogy with either Canal Zone station. Although there is scanty coverage of data for mean windspeed, mean cloudiness, the mean relative humidity for most of the area, stations which show analogy for temperature and precipitation criteria usually show at least local analogy for the other, less widely observed elements.
Maps, tables

KEYWORDS: Climatic analogs; Climatology; Tropical regions;[Australia; New Guinea; Panama C. Z.]

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| 3. REPORT TITLE CANAL ZONE ANALOGS NO. IX ANALOGS OF CANAL ZONE CLIMATE IN THE FAR EAST | |
| 4. DESCRIPTIVE NOTES (Type of report and inclusive dates) Contract Report | |
| 5. AUTHOR(S) (Last name, first name, initial) Anstey, Robert L., Ph. D. | |

| 6. REPORT DATE | 7a. TOTAL NO. OF PAGES | 7b. NO. OF REFS |
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| October 1960 | 29 | 18 |

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| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY |
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| Project Reference: 7X83-01-008 | WES |

13. ABSTRACT The climate of the Far East is compared with that of two locations in the Canal Zone: Balboa Heights, representing the drier, leeward, Pacific side of the Isthmus of Panama, and Cristobal, representing the wetter, windward, Atlantic side. Areas of analogy of pertinent climatic elements and combinations of these elements are shown on maps.

The Far East does not contain areas of complete climatic analogy to either Canal Zone station. Winter temperatures are too low in all parts of the study area to show coincidence with the three climatic elements normally used for comparison. Nearly all of the study area is comparable with the Canal Zone stations in respect to mean temperature of the warmest month. Much of the lowland area of Japan, Formosa, southern China and a small area in extreme southern Korea have mean annual precipitation analogous to Balboa Heights, but only five areas on which are analogous to Cristobal. Other climatic elements, such as mean daily maximum temperature for the warmest month, and number of wet months, show large areas with analogous, or greater than analogous, conditions. Much of Japan and southern China are analogous to Canal Zone stations in mean cloudiness of the wettest month and mean relative humidity of the driest month. Mean windspeeds in the warmest month, mean precipitation of the wettest month, and mean daily temperature range of the warmest month in nearly all of the lowland portions of the study area are analogous to Balboa Heights, but only small areas are analogous to Cristobal.

Maps, tables

KEYWORDS: Climatic analogs; Climatology; Tropical regions; [Far East; Panama Canal Zone]

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<tr><td colspan="3">3. REPORT TITLE<br>CANAL ZONE ANALOGS NO. X<br>ANALOGS OF CANAL ZONE CLIMATE IN THE PACIFIC ISLANDS</td></tr>
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<tr><td colspan="3">5. AUTHOR(S) (Last name, first name, initial)<br>Chambers, Jack V.</td></tr>
<tr><td>6. REPORT DATE<br>November 1960</td><td>7a. TOTAL NO. OF PAGES<br>35</td><td>7b. NO. OF REFS<br>25</td></tr>
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<tr><td colspan="3">10. AVAILABILITY/LIMITATION NOTICES<br>Approved for public release; distribution unlimited.</td></tr>
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</table>


13. ABSTRACT The climate of the Pacific Islands is compared with that of two localities in the Canal Zone: Balboa Heights, representing the drier, leeward, Pacific side of the Isthmus of Panama, and Cristobal, representing the wetter, windward, Atlantic side. Distribution of areas of analogy of pertinent climatic elements and combinations of these elements are shown on maps.

The temperatures of most of the Pacific area are greatly modified by the warm ocean currents. Only on the mountainous islands do the temperatures vary greatly within short vertical distances from the lowlands to the highlands. The windward slopes of the mountainous islands are the wettest areas to be found in the Pacific area. Relative humidities are high in general because of the nearness of large water areas. Cloudiness is greatest near the "heat equator" and over the ocean areas. Windspeeds are steady but not excessive in the Pacific area.

Complete 4-way analogy with both Canal Zone stations occurs in parts of the Fiji and Society Islands. Parts of the Marshall Islands are analogous to Balboa Heights and parts of the Marquesas Islands are analogous to Cristobal. The Gilbert Islands are too hot, and the Palau Islands are too wet for complete 4-way analogy. Many of the Pacific Islands have insufficient rainfall to be analogous to either Balboa Heights or Cristobal. Of the climatic elements used, the single most limiting element is the mean temperature for the coldest month. The higher slopes of the volcanic islands are too cold in winter to be analogous to either Canal Zone station. The lee exposure of Honolulu, Hawaii, is the only place analogous outside of the zone north of 20° N or south of 20° S latitude.



KEYWORDS: Climatic analogs; Climatology; Tropical regions; [Pacific Islands; Panama Canal Zone]


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3. REPORT TITLE

A UNIVERSAL SYSTEM FOR RECORDING VEGETATION

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

5. AUTHOR(S) (First name, middle initial, last name)

Pierre Dansereau

| 6. REPORT DATE | 7a. TOTAL NO. OF PAGES | 7b. NO. OF REFS |
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| c. | 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)<br>AD 206 414 |
| d. | WES Contract Report No. 3-31, Report No. 1 |

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| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY |
|---|---|
| | U. S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi |

13. ABSTRACT

This study provides a uniform and universally applicable method of describing vegetation structures in terms suitable for the analysis of the effects of vegetation on all forms of military activities. The report discusses the source of vegetation information, the features of structure, correlations of structure, a classification of formations, and a comparison of regional climaxes. The categories and symbols for recording vegetation and site conditions are presented.

KEYWORDS: Vegetation classification; Vegetation structure

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| 1. ORIGINATING ACTIVITY (Corporate author)<br>University of Montreal<br>Botanical Institute<br>Montreal, Canada | 2a. REPORT SECURITY CLASSIFICATION<br>Unclassified<br>2b. GROUP |

3. REPORT TITLE

PART II: THE SPECIAL CASE OF AQUATIC VEGETATION--AN EXAMPLE IN SOUTHERN QUEBEC

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

5. AUTHOR(S) (First name, middle initial, last name)

Pierre Dansereau

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10. DISTRIBUTION STATEMENT

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| 11. SUPPLEMENTARY NOTES Published in Proceedings of the Northeast Wildlife Conference, Montreal, Canada, 4-7 June 1958 | 12. SPONSORING MILITARY ACTIVITY<br>U. S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi |

13. ABSTRACT

This is a preliminary account of thirty-five vascular plant communities which can be recognized in freshwater habitats south of 50° Lat. N in Quebec. The bio-climatic zone in which each one occurs is indicated. The regions are delimited by the occurrence of upland forest vegetation, which is presumed to be primarily controlled by climate. Seven transects are presented in order to illustrate some of the most typical topographic and ecological conditions under which the plant associations usually occur. The influence of flooding, of slope and of substratum in their major features are shown. Several of these communities have been studied phytosociologically and special reference is made to their life-form spectrum and their structure and also to the dispersal types which they include. Finally, the dynamics and productivity of the associations are briefly evaluated.

KEYWORDS: Plants (Botany); Vegetation descriptions; Vegetation structure;[Quebec, Canada]

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| 1. ORIGINATING ACTIVITY (Corporate author)<br>FMC Corporation<br>Ordnance Division<br>San Jose, California | 2a. REPORT SECURITY CLASSIFICATION<br>Unclassified<br>2b. GROUP |

3. REPORT TITLE

A RESEARCH STUDY CONCERNING THE APPLICATION OF A FOURIER SERIES DESCRIPTION TO TERRAIN GEOMETRIES ASSOCIATED WITH GROUND MOBILITY AND RIDE DYNAMICS, PHASE 1: TERRAIN AND VEHICLE MODELS

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

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5. AUTHOR(S) (First name, middle initial, last name)

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10. DISTRIBUTION STATEMENT

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| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY<br>U. S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi |

13. ABSTRACT

Representative surface geometry profiles from those presented in the Waterways Experiment Station Technical Report No. 5-625, "Environmental Factors Affecting Ground Mobility in Thailand," Appendix E, are fitted by Fourier-series curves. Fit accuracy appears satisfactory and justifies confidence that all such microrelief profiles can be so described mathematically. The feasibility of using a Fourier-described terrain in finding the response of a vehicle traversing the terrain is confirmed by comparing the results of a digital computer program when using an arc and straight line bump description and when using a Fourier-series bump description. A simplified two-degree-of-freedom mathematical model of the M37 truck is used in this comparison. A seven-degree-of-freedom mathematical model of the M37 is made and a digital computer program developed to solve its differential equations of motion. A check is made of this program by comparing responses of the seven- and two-degree-of-freedom models to the same Fourier-defined terrain using their respective programs.

KEYWORDS: Fourier analysis; Mathematical models; Microgeometry; Mobility; Ride dynamics

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| 1. ORIGINATING ACTIVITY (Corporate author)<br>Syracuse University Research Institute<br>Dept. of Geography<br>Syracuse 10, New York | 2a. REPORT SECURITY CLASSIFICATION<br>Unclassified<br>2b. GROUP |

3. REPORT TITLE

A METHODOLOGY FOR MILITARY EVALUATION AND COMPARISON OF TROPICAL TERRAIN

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

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5. AUTHOR(S) (Last name, first name, initial)

Kline, Hibberd V.B., Jr; Bennett , Don C.
Mazzucchelli, Vincent G.; Larson, Charles C.

| 6. REPORT DATE | 7a. TOTAL NO. OF PAGES | 7b. NO. OF REFS |
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10. AVAILABILITY/LIMITATION NOTICES

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| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY |
|---|---|
| | WES |

13. ABSTRACT This report attempts to enumerate the factors of tropical terrain which have significance for military occupance of the tropics, to provide methodologies for looking into these factors, and to suggest classifications that may be applied to the factors. The factors considered include the following: relief, slope, dissection, soil moisture, soil texture, streams, inland water bodies, and ocean margins. Tables, graphs

One appendix showing results of sampling tests for dissection, relief, and slope on maps of Vega Alta, Puerto Rico.

KEYWORDS: Military operations; Terrain analysis; Terrain classification; Terrain factors; Tropical regions; [Panama Canal Zone; Puerto Rico]

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Security Classification

E

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1. ORIGINATING ACTIVITY (Corporate author)

Syracuse University Research Institute
Dept. of Geography
Syracuse 10, New York

2a. REPORT SECURITY CLASSIFICATION

Unclassified

2b. GROUP

3. REPORT TITLE

ADDENDUM:
AN APPLICATION OF A METHODOLOGY FOR MILITARY EVALUATION OF TROPICAL TERRAIN TO THE PANAMA CANAL ZONE

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Contract Report

5. AUTHOR(S) (Last name, first name, initial)

Kline, Dr. Hibberd V. B., Jr.; Mazzuccheli, Vincent G.;
Bennett, Dr. Don C.

| 6. REPORT DATE | 7a. TOTAL NO. OF PAGES | 7b. NO. OF REFS |
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| May 1959 | 15 | |

8a. CONTRACT OR GRANT NO.

DA-22-079-eng-207

b. PROJECT NO.

c.

d.

9a. ORIGINATOR'S REPORT NUMBER(S)

9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)

WES Contract Report 3-34, Addendum

10. AVAILABILITY/LIMITATION NOTICES

Approved for public release; distribution unlimited.

11. SUPPLEMENTARY NOTES

Supplement to: "A Methodology for Military Evaluation & Comparison of Tropical Terrain" 1959

12. SPONSORING MILITARY ACTIVITY

WES

13. ABSTRACT

This report is submitted as an addendum to "A Methodology for Military Evaluation and Comparison of Tropical Terrain." It represents an application and analysis of the methods described in the above report for the Panama Canal Zone. Although limited as to area and time, results applicable to other tropical areas are discussed.

Maps and graphs

KEYWORDS: Military operations; Terrain analysis; Terrain classification; Terrain factors; Tropical regions; [Panama Canal Zone]

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Security Classification

Security Classification E

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| 1. ORIGINATING ACTIVITY (Corporate author)<br>The University of South Carolina<br>Dept. of Geology, Mineralogy, and Geography | 2a. REPORT SECURITY CLASSIFICATION<br>Unclassified<br>2b. GROUP |

3. REPORT TITLE

CODING HANDBOOK, SECOND REVISED EDITION

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Contract Report

5. AUTHOR(S) (Last name, first name, initial)

Anonymous

| 6. REPORT DATE | 7a. TOTAL NO. OF PAGES | 7b. NO. OF REFS |
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| 31 May 1959 | 99 | |

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10. AVAILABILITY/LIMITATION NOTICES

Approved for public release; distribution unlimited.

| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY |
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13. ABSTRACT This is a revision of the George Washington University Code Handbook, developed as part of their Historical Records Project (contract DA 22-079-eng-141). The present revision is the product of a critical review and evaluation of the George Washington University work. It is designed to be more inclusive, more specific, and more open-ended than was the George Washington University Handbook.



KEYWORDS: Environmental factors; Handbooks; Historical records; Military operations


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| 1. ORIGINATING ACTIVITY (Corporate author) University of South Carolina, Dept. of Geology, Mineralogy, and Geography | 2a. REPORT SECURITY CLASSIFICATION Unclassified |
| | 2b. GROUP |

3. REPORT TITLE

ENVIRONMENTAL STRESSES AND EFFECTS ON MILITARY ACTIVITIES

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Contract Report

5. AUTHOR(S) (Last name, first name, initial)

Bushman, Donald O.
Petty, Julian J.

| | | |
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| 6. REPORT DATE 31 May 1959 | 7a. TOTAL NO. OF PAGES 33 | 7b. NO. OF REFS |
| 8a. CONTRACT OR GRANT NO. DA 22-079-eng-234 | 9a. ORIGINATOR'S REPORT NUMBER(S) | |
| b. PROJECT NO. DA 8-97-10-004 | | |
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| d. | WES Contract Report - 3-36, Part 2 | |

10. AVAILABILITY/LIMITATION NOTICES

Approved for public release; distribution unlimited.

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| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY WES |

13. ABSTRACT This report is a critical review and evaluation of the George Washington University (GWU) Historical Records Project conducted for the U. S. Army Engineer Waterways Experiment Station, which report, consisting of eight individually bound sections, is dated 15 September 1957. The outstanding criticism of the GWU work involves the inclusion or exclusion of data for, and bias in, the statistical analyses presented by GWU. The present report also includes modifications, additions, and deletions to the GWU work, and the "Coding Handbook, Second Revised Edition," bound separately, is considered to be a part of this report.

KEYWORDS: Environmental factors; Historical records; Military operations

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## DOCUMENT CONTROL DATA - R&D

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| 1. ORIGINATING ACTIVITY (Corporate author) U. S. Geological Survey, Military Geology Branch Dept. of the Interior Washington, D. C. | 2a. REPORT SECURITY CLASSIFICATION Unclassified<br>2b. GROUP |

3. REPORT TITLE

ANALOGS OF FORT GREELY AND FORT CHURCHILL TERRAIN IN ALASKA
VOL. I, TEXT; VOL. II, MAPS

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Contract Report

5. AUTHOR(S) (Last name, first name, initial)

Stoertz, George E.

| 6. REPORT DATE | 7a. TOTAL NO. OF PAGES | 7b. NO. OF REFS |
|---|---|---|
| June 1959 | 236 (Vol I) 24 (Vol.II) | 31 |

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| 8a. CONTRACT OR GRANT NO.<br>b. PROJECT NO. 8-97-10-004<br>c.<br>d. | 9a. ORIGINATOR'S REPORT NUMBER(S)<br>9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) WES Contract Report 3-37, Vols I and II |

10. AVAILABILITY/LIMITATION NOTICES

Approved for public release; distribution unlimited.

| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY |
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13. ABSTRACT Test areas at Ft. Greely and Ft. Churchill are compared with the terrain of Alaska. Twelve terrain factors were selected as a basis for comparing the test areas with other arctic and subarctic regions and for evaluating their suitability for testing in typical arctic and subarctic terrain. It is concluded that the two sites are together well suited for testing, but with the following qualifications: (1) The total range of terrain in the test areas would have to be utilized to realize their full potential. (2) Extreme care is needed in testing some significant terrain conditions because they occupy only a half square mile of contiguous area. (3) Inasmuch as some terrain and seasonal conditions occupy such a small area or occur so infrequently within the test areas, it would be practical to test elsewhere; several areas near Ft. Greely are suggested. (4) Evaluations are in terms of individual terrain factors and are oriented toward testing specific items of equipment engaged in a single military activity. (5) Ft. Greely is best suited to test stable conditions, while Ft. Churchill is best suited for testing seasonal conditions. Taken separately they are inadequate to test a wide range of year-round arctic and subarctic terrain conditions.
Illustrations, tables, four appendices
Volume II 25 maps

KEYWORDS: Military bases; Subarctic regions; Terrain analogs; [Alaska; Ft. Churchill, Canada; Ft. Greely, Alaska]

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Security Classification

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| 1. ORIGINATING ACTIVITY (Corporate author) U. S. Geological Survey, Military Geology Branch Dept. of the Interior Washington, D. C. | 2a. REPORT SECURITY CLASSIFICATION Unclassified |
| | 2b. GROUP |

3. REPORT TITLE

ANALOGS OF FORT GREELY AND FORT CHURCHILL TERRAIN IN CENTRAL EAST GREENLAND

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Contract Report

5. AUTHOR(S) (Last name, first name, initial)

Stoertz, George E.

| 6. REPORT DATE | 7a. TOTAL NO. OF PAGES | 7b. NO. OF REFS |
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| January 1961 | 54 | 25 |

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| 8a. CONTRACT OR GRANT NO. | 9a. ORIGINATOR'S REPORT NUMBER(S) |
| b. PROJECT NO. 8-70-09-400 | |
| c. | 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) |
| d. | WES Contract Report 3-37, AD 254 050 |

10. AVAILABILITY/LIMITATION NOTICES

Approved for public release; distribution unlimited.

| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY |
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| | WES |

13. ABSTRACT The terrain of the U. S. Army test areas at Fort Greely, Alaska, and Fort Churchill, Manitoba, Canada, is compared with the terrain of Central East Greenland with respect to eleven terrain factors, five of which are stable; the remainder exhibit marked seasonal variations. The environmental conditions of Central East Greenland that are found to be adequately represented at one or both test areas are slopes, elevations, soils, petrology, vegetation, snow cover, freezing index, and mean annual temperature. Inadequately represented conditions are related to permafrost, fresh-water ice, thawing index, and darkness.

Illustrations, tables, maps

KEYWORDS: Arctic regions; Military bases; Subarctic regions; Terrain analogs; [Ft. Churchill, Canada; Ft. Greely, Alaska; Greenland]

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|---|---|
| 1. ORIGINATING ACTIVITY (Corporate author)<br>University of Illinois<br>Department of Civil Engineering<br>Urbana, Illinois | 2a. REPORT SECURITY CLASSIFICATION<br>Unclassified<br>2b. GROUP |

3. REPORT TITLE

REPORT ON SURVEY OF LITERATURE IN CONNECTION WITH THE DYNAMIC BEARING CAPACITY OF SOILS

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

5. AUTHOR(S) (First name, middle initial, last name)

Narbey Khachaturian

| 6. REPORT DATE | 7a. TOTAL NO. OF PAGES | 7b. NO. OF REFS |
|---|---|---|
| October 1959 | 19 | 114 |

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| 8a. CONTRACT OR GRANT NO.<br>b. PROJECT NO. DA-22-079-eng-240<br>R&D Subproject No. 8-12-95-420<br>c.<br>d. | 9a. ORIGINATOR'S REPORT NUMBER(S)<br>9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)<br>WES Contract Report 3-38 |

10. DISTRIBUTION STATEMENT

Approved for public release; distribution unlimited

| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY |
|---|---|
| | U. S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi |

13. ABSTRACT

A critical survey is made of the literature on the structural dynamics of soils. Only the reports contributing to the subject matter are included. The references are presented in the following four distinct areas: (1) laboratory dynamic tests on soils, (2) field dynamic tests on soils, (3) design concepts and methods in structural dynamics, and (4) miscellaneous items of information contributing to the soil dynamics. The report contains altogether 114 entries. The important references in each group are discussed briefly.

KEYWORDS: Bibliographies; Dynamic bearing capacity; Soil strength

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|---|---|
| 1. ORIGINATING ACTIVITY (Corporate author)<br>U. S. Army Snow, Ice, and Permafrost Research Establishment<br>Corps of Engineers<br>Wilmette, Illinois | 2a. REPORT SECURITY CLASSIFICATION<br>Unclassified<br>2b. GROUP |

3. REPORT TITLE

PHOTO-INTERPRETATION OF VEGETATION, LITERATURE SURVEY AND ANALYSIS

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Contract Report

5. AUTHOR(S) (Last name, first name, initial)

Finley, Virginia P.

| 6. REPORT DATE | 7a. TOTAL NO. OF PAGES | 7b. NO. OF REFS |
|---|---|---|
| July 1960 | 40 | 229 |

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| 8a. CONTRACT OR GRANT NO.<br>b. PROJECT NO.<br>USA SIPRE Project 022. 06. 005<br>c. DA Project 8-66-02-400<br>d. | 9a. ORIGINATOR'S REPORT NUMBER(S)<br>Technical Report 69<br>9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)<br>WES Contract Report 3-43 |

10. AVAILABILITY/LIMITATION NOTICES

Approved for public release; distribution unlimited.

| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY |
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| | WES |

13. ABSTRACT The results of a literature survey on the applicability, capabilities, and limitations of existing airphoto interpretation techniques in determining certain physical properties of vegetation are reported. The interpretation of tree and scrub stands is emphasized, with special attention given to measurements of trunk diameter and spacing, canopy height and coverage, density and height of undergrowth, and type of foliage. The accuracy of measurements are examined with respect to scale, photo characteristics, seasonal effects, and light conditions. Photographic factors affecting vegetation images, vegetation characteristics obtainable from aerial photographs, and vegetation identification and its significance as an indication of terrain conditions are discussed. The appendices contain information relative to type of photography, instrumentation, species identification, physical characteristics of vegetation, and vegetative keys used in the various literature sources studied.

5 Appendices

KEYWORDS: Airphoto interpretation; State-of-the-art studies; Vegetation factors; Vegetation structure

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| 1. ORIGINATING ACTIVITY (Corporate author)<br>Syracuse University Research Institute<br>Department of Geography<br>Syracuse 10, New York | 2a. REPORT SECURITY CLASSIFICATION<br>Unclassified<br>2b. GROUP |

3. REPORT TITLE
A COMPARISON OF THE TERRAIN CHARACTERISTICS AND VEGETATION OF TROPICAL AFRICA AND PANAMA

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
Contract Report

5. AUTHOR(S) (Last name, first name, initial)
Kline, Dr. Hibberd V. B., Jr.
Bennett, Don C.
Larson, Charles C.

| 6. REPORT DATE | 7a. TOTAL NO. OF PAGES | 7b. NO. OF REFS |
|---|---|---|
| May 1958 | 76 | 325 |

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10. AVAILABILITY/LIMITATION NOTICES
Approved for public release; distribution unlimited.

| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY |
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| | WES |

13. ABSTRACT
This report shows by location and description the terrain and vegetation conditions of Panama and Tropical Africa and compares them by relevance to military operations. Comparisons are drawn by mapping analogous areas. Tables. Maps pertaining to this report are missing from the only copy at WES.

KEYWORDS: Military operations; Terrain analogs; Terrain analysis; Tropical regions; [Africa; East Africa; Equatoria; Guinea; Nigeria; Panama Canal Zone]

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| 1. ORIGINATING ACTIVITY (Corporate author)<br>Syracuse University Research Institute<br>Department of Geography<br>Syracuse, New York | 2a. REPORT SECURITY CLASSIFICATION<br>Unclassified<br>2b. GROUP |

3. REPORT TITLE

A METHODOLOGY FOR TROPICAL TERRAIN COMPARISONS

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Contract Report

5. AUTHOR(S) (First name, middle initial, last name)

Hibbera V. B. Kline, Jr., Don C. Bennett, Charles C. Larson

| 6. REPORT DATE | 7a. TOTAL NO. OF PAGES | 7b. NO. OF REFS |
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| c. | 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) |
| d. | WES Contract Report 3-57 |

10. DISTRIBUTION STATEMENT

Approved for public release; distribution unlimited.

| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY |
|---|---|
| | U. S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi |

13. ABSTRACT

This report presents the rationale for the methodology used in an earlier report, "A Comparison of the Terrain Characteristics and Vegetation of Tropical Africa and Panama," the lines of methodological investigation that were rejected, and the shortcomings of the present system. Factors considered include slope and relief, ground plan and profile, water conditions at the ground surface, occurrence of excessively steep local slopes, vegetation, and stream characteristics. Alternative methods of terrain classification and analog maps comparing Africa and Panama are also discussed.

KEYWORDS: Military operations; Terrain analogs, Terrain analysis; Terrain classification; Terrain factors, Tropical regions; [Africa; Panama Canal Zone]

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|---|---|
| 1. ORIGINATING ACTIVITY (Corporate author)<br>Missouri School of Mines and Metallurgy<br>University of Missouri, Dept's. of Civil Engineering<br>and of Geology and Geological Engineering<br>Rolla, Missouri | 2a. REPORT SECURITY CLASSIFICATION<br>Unclassified<br>2b. GROUP |

3. REPORT TITLE

TEST OF QUANTITATIVE TERRAIN DESCRIPTION SYSTEMS AT FORT LEONARD WOOD, MISSOURI

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
Contract Report

5. AUTHOR(S) (Last name, first name, initial)

Maxwell, James C.

| 6. REPORT DATE | 7a. TOTAL NO. OF PAGES | 7b. NO. OF REFS |
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| June 1962 | 88 | |

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10. AVAILABILITY/LIMITATION NOTICES

Approved for public release; distribution unlimited.

| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY |
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| | |

13. ABSTRACT

An examination of the feasibility of three systems for describing and mapping components of the natural environment. The three systems are surface geometry, microrelief, and vegetation. Surface geometry analysis is based on slope classes and the characteristic plan profile. Microrelief analysis is based on differential height, elongation, and parallelism. There is a lack of criteria to distinguish between similar microrelief descriptions. Vegetation analysis is based on a physiognomic descriptive system.

Illustrations, tables, maps. Three appendices

KEYWORDS: Military bases; Temperate regions; Terrain analysis; Terrain factors; Terrain mapping; [Fort Leonard Wood, Missouri]

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| 1. ORIGINATING ACTIVITY (Corporate author)<br>Vanderbilt University<br>Department of Civil Engineering<br>Nashville, Tennessee | 2a. REPORT SECURITY CLASSIFICATION<br>Unclassified<br>2b. GROUP |

3. REPORT TITLE
APPLICATION OF MACROGEOMETRY AND VEGETATION DESCRIPTIVE TECHNIQUES TO FORT KNOX, KENTUCKY

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
Contract Report

5. AUTHOR(S) (First name, middle initial, last name)
Annonymous

| 6. REPORT DATE | 7a. TOTAL NO. OF PAGES | 7b. NO. OF REFS |
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| 1 June 1963 | 78 | |

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| b. PROJECT NO. | |
| c. | 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) |
| d. | WES Contract 3-68 |

10. DISTRIBUTION STATEMENT
Approved for public release; distribution unlimited.

| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY |
|---|---|
| | U. S. Army Engineer Waterways Experiment Station<br>Vicksburg, Mississippi |

13. ABSTRACT
It was the purpose of this investigation to examine two geographical factors, macrogeometry and vegetation, of Fort Knox, Kentucky and environs. The study included three primary areas of investigation: (a) collection and compilation of data on macrogeometry and vegetation components, (b) examination of descriptive techniques for validity and practicability and (c) development of improved descriptive techniques.

KEYWORDS: Military bases; Surface geometry factors; Temperate regions; Terrain analysis; Vegetation descriptions; [Fort Knox, Kentucky]

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| 1. ORIGINATING ACTIVITY (Corporate author)<br>University of Tennessee<br>Dept. of Civil Engineering<br>Knoxville, Tennessee | 2a. REPORT SECURITY CLASSIFICATION<br>Unclassified<br>2b. GROUP |

3. REPORT TITLE
ENVIRONMENTAL DESCRIPTIONS OF RANGER TRAINING AREAS
PART I. MOUNTAIN TRAINING AREA, NORTH GEORGIA

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
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5. AUTHOR(S) (Last name, first name, initial)

Anonymous

| 6. REPORT DATE | 7a. TOTAL NO. OF PAGES | 7b. NO. OF REFS |
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10. AVAILABILITY/LIMITATION NOTICES

Approved for public release; distribution unlimited.

| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY |
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| | WES |

13. ABSTRACT

Discussion of the magnitude and distribution of environmental factors relating to the effectiveness of military operations and the quantitative and semiquantitative expression of these factors as they exist in the investigated area. The environmental factors of surface macrogeometry, surface microgeometry, surface composition, vegetation, and hydrologic geometry are considered. Emphasis is placed on macrogeometry and vegetation. The analysis of macrogeometry is based on the delineation of the terrain unit and the measurement of the following parameters: elongation number, relief, dissection, profile area, peakedness index, slope, and parallelism number. The analysis of vegetation is based on the life-form symbolic representation system of Dansereau.

Maps, graphs, illustrations.

KEYWORDS: Military operations; Temperate regions; Terrain analysis; Terrain factors; [Georgia]

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| 1. ORIGINATING ACTIVITY (Corporate author)<br>University of Tennessee<br>Department of Civil Engineering<br>Knoxville, Tenn. | 2a. REPORT SECURITY CLASSIFICATION<br>Unclassified<br>2b. GROUP |

3. REPORT TITLE

ENVIRONMENTAL DESCRIPTIONS OF RANGER TRAINING AREAS
PART 2. EGLIN FIELD AREA, FLORIDA

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Contract Report

5. AUTHOR(S) (Last name, first name, initial)

Anonymous

| 6. REPORT DATE | 7a. TOTAL NO. OF PAGES | 7b. NO. OF REFS |
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| 31 August 1964 | 129 + 103 in Appendix | 34 |

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10. AVAILABILITY/LIMITATION NOTICES

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| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY |
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| | WES |

13. ABSTRACT


Discussion of the magnitude and distribution of environmental factors relating to the effectiveness of military operations and the quantitative and semiquantitative expression of these factors as they exist in the investigated area. The environmental factors of surface macrogeometry, surface composition, vegetation, and hydrologic geometry are considered. Emphasis is placed on macrogeometry and vegetation. The analysis of macrogeometry is based on the delineation of the terrain unit and the measurement of the following parameters: elongation number, relief, dissection, profile area, peakedness index, slope and parallelism number. The analysis of vegetation is based on the life-form symbolic representation of Dansereau.

Illustrations, tables, maps. One appendix (separately bound)



KEYWORDS: Military bases; Military operations; Temperate regions; Terrain analysis; Terrain factors; [Eglin Field, Florida]


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Security Classification

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| 1. ORIGINATING ACTIVITY (Corporate author) University of Tennesseee Department of Civil Engineering Knoxville, Tennessee | | 2a. REPORT SECURITY CLASSIFICATION Unclassified |
| | | 2b. GROUP |
| 3. REPORT TITLE ENVIRONMENTAL DESCRIPTIONS OF RANGER TRAINING AREAS PART 3. FORT BENNING AREA, GEORGIA | | |
| 4. DESCRIPTIVE NOTES (Type of report and inclusive dates) Contract Report | | |
| 5. AUTHOR(S) (Last name, first name, initial) Anonymous | | |
| 6. REPORT DATE 31 August 1964 | 7a. TOTAL NO. OF PAGES 138 + 51 in Append | 7b. NO. OF REFS 27 |
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| c. | 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) | |
| d. | WES Contract Report 3-70, Part 3 | |
| 10. AVAILABILITY/LIMITATION NOTICES Approved for public release; distribution unlimited. | | |
| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY WES | |

13. ABSTRACT


Discussion of the magnitude and distribution of environmental factors relating to the effectiveness of military operations and the quantitative and semiquantitative expression of these factors as they exist in the investigated area. The environmental factors of surface macrogeometry, surface composition, vegetation, and hydrologic geometry are considered. Emphasis is placed on macrogeometry and vegetation. The analysis of macrogeometry is based on the delineation of the terrain unit and the measurement of the following parameters: elongation number, relief, dissection, profile area, peakedness index, slope, and parallelism number. The analysis of vegetation is based on the life-form symbolic representation of Dansereau.

Illustrations, tables, maps. One appendix (separately bound)



KEYWORDS: Military bases; Military operations; Temperate regions; Terrain analysis; Terrain factors; [Fort Benning, Georgia]


DD FORM 1 JAN 64 1473

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## DOCUMENT CONTROL DATA - R&D

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|---|---|
| 1. ORIGINATING ACTIVITY (Corporate author)<br>Marshall University<br>Huntington, West Virginia | 2a. REPORT SECURITY CLASSIFICATION<br>Unclassified<br>2b. GROUP |

3. REPORT TITLE

QUANTITATIVE PHYSIOGNOMIC ANALYSIS OF THE VEGETATION OF THE FLORIDA EVERGLADES

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Contract Report

5. AUTHOR(S) (Last name, first name, initial)

Mills, Howard L.

| 6. REPORT DATE | 7a. TOTAL NO. OF PAGES | 7b. NO. OF REFS |
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| April 1963 | 69 | 8 |

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| 8a. CONTRACT OR GRANT NO.<br>DA-22-079-eng-322<br>b. PROJECT NO.<br>c.<br>d. | 9a. ORIGINATOR'S REPORT NUMBER(S)<br><br>9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)<br>WES Contract Report 3-72, AD 450 738 |

10. AVAILABILITY/LIMITATION NOTICES

Approved for public release; distribution unlimited.

| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY |
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13. ABSTRACT

This study was concerned with the refinement of a descriptive system and also with sampling methods adaptable to quantitative analysis of the vegetation structure of the Florida Everglades. A physiognomic basis of classification, as opposed to floristic analysis, meets all the essential requirements for the treatment of vegetational effects on military operations. Using the structural cell concept, a structural diagram can be constructed, based on any chosen structural element, from which the spatial distribution of that element can be quantified. The rationale for determining the size of the structural cell is explained, as are the relatively simple field methods employed in this determination. The methods utilized in construction of the structural diagram, with incorporation of the varying vegetation characteristics, are discussed and illustrated by graphs. Figures 1 through 62, each with parts A and B, and sometimes C, present the structural diagrams and the field data. Maps, illustrations

KEYWORDS: Vegetation structure; [Florida, Everglades]

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*(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)*

| 1. ORIGINATING ACTIVITY (Corporate author) | 2a. REPORT SECURITY CLASSIFICATION |
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| Drexel Institute of Technology<br>Dept. of Civil Engineering<br>Philadelphia, 4, Pa. | Unclassified |
| | 2b. GROUP |

3. REPORT TITLE

PRELIMINARY REPORT: A SYSTEM FOR DESCRIBING, CLASSIFYING, MAPPING AND COMPARING SURFACE-WATER BODIES FOR MILITARY PURPOSES

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Contract Report

5. AUTHOR(S) (Last name, first name, initial)

Remson, Irwin; Stiefel, Robert C.; Giles, Ronald V.

| 6. REPORT DATE | 7a. TOTAL NO. OF PAGES | 7b. NO. OF REFS |
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| 30 June 1961 | 101 | 23e |

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| d. | WES Contract Report 3-78, Report 1 |

10. AVAILABILITY/LIMITATION NOTICES

Approved for public release; distribution unlimited.

| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY |
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| | WES |

13. ABSTRACT

This preliminary report presents a system for describing, classifying, mapping, and comparing surface-water bodies in terms of those physical characteristics pertinent to military activities. The system also provides means for describing, classifying, mapping, and comparing areas that are of military importance in terms of the characteristics of their surface-water bodies.

The proposed system consists essentially of base maps with interpretive overlays summarizing hydrologic characteristics of the area or elements of classification.

The hydrologic elements of military importance are grouped into three types: (a) Standing bodies of water (lake, inland sea, reservoir, snowfield); (b) flooded or wet areas (marsh, swamp, irrigated area; area subject to inundation); (c) water courses (stream, estuary, glacier, dry-water courses, artificial water course-canal, ditch, etc.). The characteristics of the first two of these are areal extent, depth, distances to nearby water bodies, bank and shore characteristics, etc. and for the third type, the characteristics are form (meandering, braided, etc.), length and width, velocity and discharge, control structures, etc. The classification is geared in part to the current availability of data. This has the advantage of being immediately usable, but it has the disadvantage of being restricted by the lack of certain data, and these restrictions are perpetuated. It is recognized that a system should be devised which would reveal the data needs so that data-collection programs could be revised to serve the requirements of the military more adequately.

KEYWORDS: Hydrologic geometry; Hydrologic geometry classification; Hydrologic geometry mapping; Military operations

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|---|---|
| 1. ORIGINATING ACTIVITY (Corporate author) Drexel Institute of Technology Dept. of Civil Engineering Philadelphia, Pa. | 2a. REPORT SECURITY CLASSIFICATION Unclassified |
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3. REPORT TITLE
SOME SYSTEMS FOR DESCRIBING, CLASSIFYING, MAPPING AND COMPARING SURFACE-WATER BODIES FOR MILITARY PURPOSES

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
Contract Report

5. AUTHOR(S) (Last name, first name, initial)
Remson, Irwin; Giles, Ronald V.; Boles, Elmore J.; Stiefel, Robert C.

| 6. REPORT DATE | 7a. TOTAL NO. OF PAGES | 7b. NO. OF REFS |
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| b. PROJECT NO. | DIT Project No. 76B |
| c. | 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) |
| d. | WES Contract Report 3-78, Report 2 |

10. AVAILABILITY/LIMITATION NOTICES

Approved for public release; distribution unlimited.

| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY |
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| | WES |

13. ABSTRACT This is the second and concluding annual report of studies designed to prepare a classification of surface-water bodies for military purposes. The first annual report described a tentative restrictive system designed largely for trafficability purposes. This report outlines the general philosophy that has evolved during the two year study of this problem. It discusses the variety of systems and methods worked on this year, and presents the conclusions and accomplishments. Because of specified difficulties it is believed that any attempt to classify environments in terms of military effect is foredoomed to failure. Instead, the systems presented attempt to classify in terms of environmental properties. The proposed solution includes two closely related approaches. The first is the development of systems for storing data about environmental properties. The second is the development of systems for classifying environmental properties. Because of fiscal and time exigencies, most of the systems are presented in rough and incomplete form. Furthermore, the report has loose ends and a notable lack of polish, but it presents an accurate summary of the project accomplishments during the report period.
Diagrams, tables, one appendix

KEYWORDS: Hydrologic geometry; Hydrologic geometry classification; Hydrologic geometry mapping; Military operations

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|---|---|
| 1. ORIGINATING ACTIVITY (Corporate author) University of Southern California Los Angeles, California | 2a. REPORT SECURITY CLASSIFICATION Unclassified |
| | 2b. GROUP |

3. REPORT TITLE

MAPPING, CLASSIFICATION, AND QUANTITATIVE EXPRESSION OF MICRORELIEF FEATURES

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Contract Report

5. AUTHOR(S) (Last name, first name, initial)

Anonymous

| 6. REPORT DATE | 7a. TOTAL NO. OF PAGES | 7b. NO. OF REFS |
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| 5 November 1962 | 40 | 10 |

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| b. PROJECT NO. | |
| c. | 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) |
| d. | WES Contract Report 3-80 |

10. AVAILABILITY/LIMITATION NOTICES

Approved for public release; distribution unlimited.

| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY |
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| | WES |

13. ABSTRACT

Mapping of microrelief features utilizing radial profiles at 15° intervals surveyed from a common point is the most rapid and applicable method of data collection. Surface roughness is considered a vector quantity. Fourier analysis of terrain profiles is a means of considering individual components of the roughness vector. A method of processing terrain curves for high frequencies is presented and the desired components are determined as: smoothness, similarity of one portion of the curve with other portions, variability in the height of the various peaks, width of the significant peaks, height of the most significant peaks, and jaggedness.

Illustrations, graphs.

KEYWORDS: Fourier analysis; Microgeometry; Microgeometry classification; Microgeometry mapping

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(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

**1. ORIGINATING ACTIVITY (Corporate author)**
University of Southern California
Los Angeles, California

**2a. REPORT SECURITY CLASSIFICATION**
Unclassified

**2b. GROUP**

**3. REPORT TITLE**
A STUDY OF MICRORELIEF: ITS MAPPING, CLASSIFICATION, AND QUANTIFICATION BY MEANS OF A FOURIER ANALYSIS

**4. DESCRIPTIVE NOTES (Type of report and inclusive dates)**
Contract Report

**5. AUTHOR(S) (Last name, first name, initial)**
Stone, Richard O.; Dugundji, James

| 6. REPORT DATE | 7a. TOTAL NO. OF PAGES | 7b. NO. OF REFS |
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**9a. ORIGINATOR'S REPORT NUMBER(S)**

**9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)**
AD 450 828
WES Contract Report 3-82

**10. AVAILABILITY/LIMITATION NOTICES**
Approved for public release; distribution unlimited.

**11. SUPPLEMENTARY NOTES**

**12. SPONSORING MILITARY ACTIVITY**
WES

**13. ABSTRACT**

Twenty-two microterrains were mapped and detailed profiles constructed. These profiles were used in a Fourier series and processed by a digital computer to determine (1) expected changes in level as a profile is traversed, (2) the expected height of major relief features, (3) the expected steepness of relief features encountered, and (4) the extent to which there is periodicity. In addition, an avoidance factor and a cell length are determined. Three general classes of microrelief terrains were established on the basis of these computations.

Tables, maps, one appendix

KEYWORDS: Fourier analysis; Microgeometry; Microgeometry classification; Microgeometry mapping

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| 1. ORIGINATING ACTIVITY (Corporate author)<br>Vanderbilt University<br>Department of Civil Engineering<br>Nashville 5, Tenn. | | 2a. REPORT SECURITY CLASSIFICATION<br>Unclassified<br>2b. GROUP |
| 3. REPORT TITLE<br>MANUAL: A TECHNIQUE FOR MACROGEOMETRY TERRAIN ANALYSIS | | |
| 4. DESCRIPTIVE NOTES (Type of report and inclusive dates)<br>Contract Report | | |
| 5. AUTHOR(S) (Last name, first name, initial)<br>Anonymous | | |
| 6. REPORT DATE<br>1 March 1963 | 7a. TOTAL NO. OF PAGES<br>45 | 7b. NO. OF REFS |
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| 10. AVAILABILITY/LIMITATION NOTICES<br>Approved for public release; distribution unlimited. | | |
| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY<br>WES | |

13. ABSTRACT

A procedure for the analysis of terrain macrogeometry. Utilizing six parameters. The following five parameters define the configuration of a terrain unit: relief, dissection, profile area, peakedness index, and elongation. The sixth parameter, parallelism, describes the orientation of a group of terrain units.

Tables and maps

KEYWORDS: Surface geometry; Surface geometry factors

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| 1. ORIGINATING ACTIVITY (Corporate author)<br>Vanderbilt University<br>Department of Civil Engineering<br>Nashville 5, Tenn. | 2a. REPORT SECURITY CLASSIFICATION<br>Unclassified<br>2b. GROUP |

3. REPORT TITLE

APPLICATION OF TERRAIN DESCRIPTIVE TECHNIQUES TO FORT KNOX, KENTUCKY

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Contract Report

5. AUTHOR(S) (Last name, first name, initial)

Anonymous

| 6. REPORT DATE | 7a. TOTAL NO. OF PAGES | 7b. NO. OF REFS |
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| b. PROJECT NO. | |
| c. | 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) |
| d. | WES Contract Report 3-94, AD 672 498 |

10. AVAILABILITY/LIMITATION NOTICES

Approved for public release; distribution unlimited.

| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY |
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13. ABSTRACT

Investigation of terrain descriptive techniques for the quantitative description of the geographical area of Fort Knox, Kentucky. Microrelief and vegetative descriptor systems were not examined. Surface macrogeometry was emphasized. The descriptive terrain factor of characteristic slope, characteristic relief, slope occurrence, parallelism, profile area, elongation, and peakedness index were utilized. Comparisons are made with the Yuma Handbook Methodology (TR.3-506).

Tables, illustrations, maps. One Appendix

KEYWORDS: Military bases; Surface geometry factors; Temperate regions; Terrain analysis; [Fort Knox, Kentucky]

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1. ORIGINATING ACTIVITY (Corporate author)
Texas Instruments, Inc.
Geosciences Division
Dallas, Texas

2a. REPORT SECURITY CLASSIFICATION
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2b. GROUP

3. REPORT TITLE
PHASE I, SYSTEM ANALYSIS FOR A WATERWAYS EXPERIMENT STATION TERRAIN ANALYSIS RADAR (PROJECT WESTAR); FINAL REPORT

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
Final report

5. AUTHOR(S) (First name, middle initial, last name)
Anonymous

| 6. REPORT DATE | 7a. TOTAL NO. OF PAGES | 7b. NO. OF REFS |
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8a. CONTRACT OR GRANT NO. DA-22-069-eng-295

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9a. ORIGINATOR'S REPORT NUMBER(S)

9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)
WES Contract Report No. 4-96, No. 1

10. DISTRIBUTION STATEMENT
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11. SUPPLEMENTARY NOTES
Technical information contained herein included in WES Technical Report 3-693, Report 2, and Technical Report 3-727

12. SPONSORING MILITARY ACTIVITY
U. S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi

13. ABSTRACT

The object of the investigation was, first, to find out if a radar can be used in a laboratory to provide data on terrain studies, and, if so, to find out whether such a radar can be made from conventional simple components and if necessary, used in an airplane. The investigation was carried out in three steps, which were (1) Radar Study, (2) Facility Design, and (3) Specimen Design. No existing radar is suitable for use both in the laboratory and in airborne operation. However, existing radars and radar components in the $K_a$-, X-, C-, and P-bands can be modified so as to be used in both laboratory and air. It was recommended that the radar used in WESTAR be the AN/TPS-21 or its equivalent, with required modifications. The operating variables of this radar have been used to set the specifications of the laboratory structure and the specimen containers. The specifications and results in this report constitute the recommendations for the establishment of the laboratory facility.

KEYWORDS: Laboratory tests; Radar; Radar equipment; Remote sensing; Soil tests (Laboratory); Systems analysis; Terrain analysis

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**DOCUMENT CONTROL DATA - R & D**

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1. ORIGINATING ACTIVITY (Corporate author)
Texas Instruments, Inc.
Science Services Division
Dallas, Texas

2a. REPORT SECURITY CLASSIFICATION
Unclassified

2b. GROUP

3. REPORT TITLE
PHASE II, SYSTEM IMPLEMENTATION WATERWAYS EXPERIMENT STATION TERRAIN ANALYSIS RADAR (PROJECT WESTAR); FINAL REPORT AND ENGINEERING HANDBOOK

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
Final report

5. AUTHOR(S) (First name, middle initial, last name)
Anonymous

6. REPORT DATE
January 1963

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9a. ORIGINATOR'S REPORT NUMBER(S)

9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)
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WES Contract Report No. 4-96, No. 2

10. DISTRIBUTION STATEMENT
Approved for public release; distribution unlimited.

11. SUPPLEMENTARY NOTES
Technical information contained herein included in WES Technical Report No. 3-693, Report 2, and Technical Report 3-727

12. SPONSORING MILITARY ACTIVITY
U. S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi

13. ABSTRACT

Texas Instruments is assisting in the study of terrain analysis by radar in a laboratory environment. The design of the radar laboratory was established in Phase I, System Analysis, of the project. This Phase II report includes description of Phase I design and fabrication and installation of designated components of the WESTAR facility. These components are from three sources: (a) government furnished equipment, e.g. various subunits of the operational radar set AN/TPS-33; (b) Texas Instruments fabrication and model shops, e.g. the control console; and (c) commercial vendors, e.g. radar antennas. Other than system control and read-out elements, the system operates in an open-end archway 44 ft long and 100 ft wide at the base with an arch radius of 50 ft. A carriage, mounting the receiver-transmitters, a control junction box, and radar antennas, is track mounted to the arch and is capable of traversing a segment of the arch from the zenith to nearly ground level. Terrain specimens are prepared in wooden containers, track mounted on the floor of the WESTAR facility. Preliminary laboratory testing, calibration, and data collection indicate system losses are negligible, the radar system is functioning as designed and is expected to collect determinative terrain information at all radar frequencies provided.

KEYWORDS: Laboratory tests; Radar; Radar equipment; Remote sensing; Soil tests (Laboratory); Terrain analysis

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| 1. ORIGINATING ACTIVITY (Corporate author)<br>Texas Instruments, Inc.<br>Science Services Division<br>Dallas, Texas | 2a. REPORT SECURITY CLASSIFICATION<br>Unclassified<br>2b. GROUP |

3. REPORT TITLE

PHASE III, ANALYSIS OF RESULTS, WATERWAYS EXPERIMENT STATION TERRAIN ANALYSIS RADAR (PROJECT WESTAR): FINAL REPORT

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final report

5. AUTHOR(S) (First name, middle initial, last name)

Anonymous

| 6. REPORT DATE | 7a. TOTAL NO. OF PAGES | 7b. NO. OF REFS |
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| b. PROJECT NO. 8570-05-001-04 | |
| c. | 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) AD 465 403 |
| d. | WES Contract Report No. 4-96, No. 3 |

10. DISTRIBUTION STATEMENT

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| 11. SUPPLEMENTARY NOTES Technical information contained herein included in WES Technical Report No. 3-693, Report 2, and Technical Report No. 3-727 | 12. SPONSORING MILITARY ACTIVITY<br>U. S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi |

13. ABSTRACT

The design and final installation requirements of the radar laboratory were established in Phase I and Phase II reports, respectively, (Texas Instruments, 1961 and 1963). This report completes Phase III in the study of terrain analysis by radar in a laboratory environment and, from the required interpretation, is Texas Instrument's final analysis and appraisal of Project WESTAR. The analysis discloses certain results of the measurement program, reexamines the total experimental program and supplies the basis for recommendations of future radar terrain analysis for mobility determinations. Project WESTAR is considered successful in that it has shown empirical relationships between radar reflectance and percent moisture content for sands, clays, and silts and that penetration depths and soil dielectric constants can be measured as a function of frequency and percent moisture.

KEYWORDS: Laboratory tests; Radar; Radar equipment; Soil moisture prediction; Soil tests (Laboratory); Terrain analysis; Remote sensing

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| 1. ORIGINATING ACTIVITY (Corporate author)<br>Texas Instruments, Inc.<br>Geosciences Operations, Science Services Division<br>Dallas, Texas | 2a. REPORT SECURITY CLASSIFICATION<br>Unclassified<br>2b. GROUP |
| 3. REPORT TITLE<br>FINAL REPORT, WATERWAYS EXPERIMENT STATION TERRAIN ANALYSIS GAMMA (PROJECT WESTAG) | |
| 4. DESCRIPTIVE NOTES (Type of report and inclusive dates)<br>Final report | |
| 5. AUTHOR(S) (First name, middle initial, last name)<br>Anonymous | |
| 6. REPORT DATE<br>March 1964 | 7a. TOTAL NO. OF PAGES: 154<br>7b. NO. OF REFS: 25 |
| 8a. CONTRACT OR GRANT NO.<br>b. PROJECT NO.<br>c.<br>d. | 9a. ORIGINATOR'S REPORT NUMBER(S)<br>9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)<br>WES Contract Report No. 4-100 |
| 10. DISTRIBUTION STATEMENT<br>Approved for public release; distribution unlimited. | |
| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY<br>U. S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi |

13. ABSTRACT

A laboratory gamma ray spectrometer has been installed at the Waterways Experiment Station, Vicksburg, Mississippi, and a program of controlled soil sample measurements has been initiated to investigate the possibilities in remotely determining soil type and trafficability parameters by the characteristics of the natural gamma ray spectra. Preliminary measurements on the Long Lake clay, Openwood Street silt, and Yuma sand have shown that the characteristic natural radioelement contents can be measured accurately and may be useful in identifying the soil type. Distortion of the gamma ray spectrum, which is caused by scattering and absorption in the interstitial moisture, shows sufficient measurable variation to offer definite promise as a basis for a future remote moisture measuring technique. Future work should include laboratory measurement of many more varieties of the major soil types to determine ranges of values within types with varying moisture content. The laboratory work should be supplemented by a carefully designed field program to investigate in-place variables not easily reproducible in the laboratory. These include variations within soil types, effects of meterologic variables, vegetation effects, and geometry modifications.

KEYWORDS: Gamma ray spectrometer; Gamma rays; Laboratory tests; Remote sensing; Soil classification; Soil moisture prediction; Soil tests (Laboratory)

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Security Classification

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| 1. ORIGINATING ACTIVITY (Corporate author)<br>Marshall University<br>Huntington, West Virginia | 2a. REPORT SECURITY CLASSIFICATION<br>Unclassified<br>2b. GROUP |

3. REPORT TITLE

THE PHYSIOGNOMY OF VEGETATION: A QUANTITATIVE APPROACH TO VEGETATION GEOMETRY BASED UPON THE STRUCTURAL CELL CONCEPT AS THE MINIMUM SAMPLE SIZE: CONCEPTS AND ANALYTICAL METHODS (VOL. 1); APPENDIX

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

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5. AUTHOR(S) (First name, middle initial, last name)

Mills, Howard L.

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| 6. REPORT DATE<br>May 1964 | 7a. TOTAL NO. OF PAGES<br>241 (Vol. 1) | 7b. NO. OF REFS<br>12 |
| 8a. CONTRACT OR GRANT NO. DA-22-079-eng-322<br>b. PROJECT NO. AMC No. 1-T-0-21701-A-131<br>c.<br>d. | 9a. ORIGINATOR'S REPORT NUMBER(S)<br><br>9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)<br>AD 617 727 (Vol 1); AD 617 728 (Appendix)<br>WES Contract Report 4-103 | |

10. DISTRIBUTION STATEMENT

Approved for public release; distribution unlimited.

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| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY<br>WES |

13. ABSTRACT


A descriptive system for vegetative physiognomy by parameter symbols is developed diagrammatically. Equations are given for nearest neighbor in a uniform distribution. Formulas validating the structural cell sampling procedures are interpreted.

Illustrations, maps, tables, diagrams. One appendix (separately bound) titled, "Field Data, Structural Diagrams and Sampling Area Locations of the Vegetation of Camp McCoy, Wisconsin."



KEYWORDS: Military bases; Vegetation structure; [Camp McCoy, Wisconsin]


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**DOCUMENT CONTROL DATA - R & D**

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|---|---|
| 1. ORIGINATING ACTIVITY (Corporate author)<br>Purdue University<br>Engineering Experiment Station<br>Lafayette, Indiana | 2a. REPORT SECURITY CLASSIFICATION<br>Unclassified<br>2b. GROUP |
| 3. REPORT TITLE<br>STATISTICAL ANALYSES OF TRAFFICABILITY DATA | |
| 4. DESCRIPTIVE NOTES (Type of report and inclusive dates) | |
| 5. AUTHOR(S) (First name, middle initial, last name)<br>Paul Irick | |
| 6. REPORT DATE<br>November 1953 | 7a. TOTAL NO. OF PAGES<br>28 / 7b. NO. OF REFS |
| 8a. CONTRACT OR GRANT NO. DA-22-079-eng-65<br>b. PROJECT NO.<br>c.<br>d. | 9a. ORIGINATOR'S REPORT NUMBER(S)<br>9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)<br>WES Contract Report No. 3-108 |
| 10. DISTRIBUTION STATEMENT<br>Approved for public release; distribution unlimited. | |
| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY<br>U. S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi |

13. ABSTRACT

In this study a large amount of weather and trafficability data (precipitation, cone index, remolding index, soil moisture content, and soil density) collected from May 1952 to May 1953 at one 80 x 40 ft site (Crosby) at Lafayette, Indiana, were reduced to two related analyses. In the first of these the extent of sampling variation in certain of the measured variables and the degree to which their variation could be expressed in terms of functional relationships with concomitant variables were determined. In the second analysis, various explicit functional relationships were determined. In particular, the study assesses the reliability of cone penetrometer data obtained by sampling procedures, then evolves prediction equations for cone index means in terms of variables such as rainfall, soil moisture, and soil density. In a special case it was found that roughly 10 percent of cone index-mean variation must be attributed to sampling variation and that over 80 percent of the nonsampling variation could be accounted for from the relations of cone index means with rainfall and soil moisture.

KEYWORDS: Meteorological data; Soil density; Soil moisture; Soil property relations; Soil property variations; Soil strength; Statistical analysis; Trafficability data; [Lafayette, Indiana]

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| 1. ORIGINATING ACTIVITY (Corporate author) | 2a. REPORT SECURITY CLASSIFICATION |
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| Wilson, Nuttall, Raimond Engineers, Inc. Chestertown, Maryland | Unclassified |
| | 2b. GROUP |

3. REPORT TITLE

OBSERVING, ANALYZING, AND FORECASTING THE STATE OF THE GROUND

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final report

5. AUTHOR(S) (Last name, first name, initial)

Grenke, W. C.

| 6. REPORT DATE | 7a. TOTAL NO. OF PAGES | 7b. NO. OF REFS |
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| May 1965 | 230 | 1229 |

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| 8a. CONTRACT ~~OR GRANT~~ NO. DA-22-079-eng-354 | 9a. ORIGINATOR'S REPORT NUMBER(S) |
| b. PROJECT NO. | |
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10. AVAILABILITY/LIMITATION NOTICES

Approved for public release; distribution unlimited.

| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY |
|---|---|
| | Chief of Research and Development Department of the Army Washington, D. C. 20310 |

13. ABSTRACT

A study was made to determine the feasibility of developing an integrated system for observing, analyzing, and forecasting the state of the ground. The study relied chiefly on an extensive literature review, a worldwide questionnaire survey, and interviews with personnel of U. S. civilian and military agencies with an interest in the subject. It was found that the most widely useful indicators of the state of the ground were soil moisture content, soil temperature and soil strength. It was further found that while information of this type is being collected at numerous sites around the world, there is little evidence of standardization of instruments or depths and frequencies of observations. Suitable methods are presently available for developing an integrated state-of-the-ground system, but improvements in the methods are desirable. Three systems are suggested, one for international use, one for civilian use in this country, and a third for U. S. military use on a worldwide basis.

KEYWORDS: Environmental analysis; Soil moisture; Soil strength; Soil temperature; State-of-the-art studies; State of the ground; Terrain analysis

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| 1. ORIGINATING ACTIVITY (Corporate author)<br>Wilson, Nuttall, Raimond, Engineers, Inc.<br>Chestertown, Maryland | 2a. REPORT SECURITY CLASSIFICATION<br>Unclassified<br>2b. GROUP |

3. REPORT TITLE

AN EXPLORATORY STUDY OF THE EFFECTS OF TERRAIN SURFACE OBSTACLES ON VEHICLE PERFORMANCE (Final Draft)

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
Final Draft Report

5. AUTHOR(S) (Last name, first name, initial)

Cohron, G. T. and Werner, R. A.

| | | |
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| 6. REPORT DATE<br>March 1965 | 7a. TOTAL NO. OF PAGES<br>223 | 7b. NO. OF REFS<br>0 |
| 8a. CONTRACT OR GRANT NO.<br>DA-22-079-eng-394<br>b. PROJECT NO.<br>c. ARPA Order No. 400<br>d. | 9a. ORIGINATOR'S REPORT NUMBER(S)<br>Contract Report No. 113-2<br>AD A032 584<br>9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)<br>WES Contract Report 3-120 | |

10. AVAILABILITY/LIMITATION NOTICES

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| 11. SUPPLEMENTARY NOTES<br>Prepared under contract with U. S. Army Engineer Waterways Experiment Station, Vicksburg, Miss. | 12. SPONSORING MILITARY ACTIVITY<br>Advanced Research Projects Agency<br>Directorate of Remote Area Conflict |

13. ABSTRACT

This was the first major attempt to correlate terrain surface obstacles (lateral, longitudinal, and vertical) with vehicle performance. Purpose of the study was to develop and/or evaluate (1) measurement systems necessary to permit quantitative description of vehicle performance and the terrain on which vehicles are operated (2) test methodology including proper experimental design (3) methods of analysis leading to quantitative vehicle-performance relations (4) approximate limits for both "immobilization" and "no-effect" values of important parameters and (5) a study plan which will include an analytical framework within which more extensive future studies should be analyzed. Analysis of test data revealed the important terrain-vehicle relations for cross-country mobility and the proper methods of measuring and analyzing important terrain-vehicle parameters.

KEYWORDS: Obstacles; Obstacle-wheel interaction; Offroad mobility; Performance tests (Vehicles); Surface geometry factors; Terrain-vehicle interaction; Test procedures; Vehicle performance

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| 1. ORIGINATING ACTIVITY (Corporate author)<br>Kasetsart University<br>Bangkok, Thailand | 2a. REPORT SECURITY CLASSIFICATION<br>Unclassified<br>2b. GROUP |

3. REPORT TITLE

GREAT SOIL GROUP SURVEY OF SELECTED STUDY AREAS IN THAILAND

4. DESCRIPTIVE NOTES (Type of report and inclusive dates) Final report in two volumes: volume 1, Summary Report; volume 2, Appendices A through G

5. AUTHOR(S) (Last name, first name, initial)

Santhad Rojanasoonthon

| 6. REPORT DATE | 7a. TOTAL NO. OF PAGES | 7b. NO. OF REFS |
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| June 1966 | 43 | 18 |

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13. ABSTRACT

This report presents a summary of the methods and techniques used in the survey and describes (a) the physiographic regions of Thailand and their occurrence within the study areas, (b) the great soil groups identified in this survey, (c) the map units and the occurrence of these map units in the physiographic regions of Thailand, and (d) the general soil conditions of Southeast Asia.

Interim reports for each of the seven study areas were prepared and are included as Appendices A through G to this report. Each report includes a general description of the environmental conditions of the study area as related to the individual soils mapped. Because of a shortage of time and lack of adequate facilities, only a few laboratory data are included.

The maps presented in the appendices are to be considered as reconnaissance soil maps because of the small map scale used and the minimum amount of work performed in the field, particularly in areas without reasonable access routes.

KEYWORDS: Great soil groups; Soil classification; Soil maps; Soil science; Tropical regions; [Thailand]

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1. ORIGINATING ACTIVITY (Corporate author)

Soil Survey Division, Land Development Department
Royal Thai Government
Bangkok, Thailand

2a. REPORT SECURITY CLASSIFICATION

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2b. GROUP

3. REPORT TITLE

SOIL SERIES SURVEY OF SELECTED STUDY AREAS IN THAILAND

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final report in seven volumes, consisting of Summary Report and Appendixes A-F.

5. AUTHOR(S) (First name, middle initial, last name)

Moormann, F. R.
Dent, F. J.
Moncharoen, Lek
Libby, D. A.
Cheutongdee, Mana
Omakupt, Manu
Charoenpong, Suraphon

| 6. REPORT DATE | 7a. TOTAL NO. OF PAGES | 7b. NO. OF REFS |
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AD 489 699 (App B); AD 489 700 (App C);
AD 489 701 (App D); AD 807 703 (App E);
AD 489 702 (App F)

12. SPONSORING MILITARY ACTIVITY

Advanced Research Projects Agency
Directorate of Remote Area Conflict
Washington, D. C. 20314

13. ABSTRACT

The study reported herein presents a summary of the methods and techniques used in the survey and correlates the various soil series with great soil groups and subgroups and physiographic position. The corresponding taxa of the new USDA soil classification system were also indicated. A summary is given of the geomorphologic relations between the various soil series. For each of the selected study areas, detailed descriptive reports accompanied by soil maps on a scale of 1:50,000 were prepared and included as Appendixes A through F to this report. Each appendix includes a general description of natural conditions in the study area as related to soil conditions, as well as a detailed description of the mapping units.

KEYWORDS: Soil classification; Soil maps; Soil science; Soil series; Tropical regions; [Thailand]

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| 1. ORIGINATING ACTIVITY (Corporate author)<br>New York Botanical Garden<br>Bronx Park, Bronx, N. Y. 10458 | 2a. REPORT SECURITY CLASSIFICATION<br>Unclassified<br>2b. GROUP |

3. REPORT TITLE

A METHODOLOGICAL CRITIQUE OF VEGETATION RECORDING SYSTEMS

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final report

5. AUTHOR(S) (First name, middle initial, last name)

Pierre Dansereau
Peter F. Buell
Ronald Dagon

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| 6. REPORT DATE<br>November 1966 | 7a. TOTAL NO. OF PAGES<br>64 | 7b. NO. OF REFS<br>50 |
| 8a. CONTRACT OR GRANT NO.<br>DA-22-079-eng-332<br>b. PROJECT NO.<br>1-V-0-25001-A-131<br>c.<br>d. | 9a. ORIGINATOR'S REPORT NUMBER(S)<br><br>9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)<br>AD 813 749<br>WES Contract Report 3-163 | |

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| 11. SUPPLEMENTARY NOTES<br>Conducted for<br>U. S. Army Engineer Waterways Experiment Station, Vicksburg, Miss. | 12. SPONSORING MILITARY ACTIVITY<br>U. S. Army Materiel Command<br>Washington, D. C. |

13. ABSTRACT

Since the initial development of the Dansereau scheme for describing and recording the structure (or physiognomy) of vegetation in 1951, a number of significant modifications to the scheme have been introduced, both by Dansereau and others. Notable variants include those by Mills and Clagg (1963, 1964) and by the Waterways Experiment Station. These variants are examined for consistency and logic, for the flexibility of each, and for the study of possible alternatives. Suggestions for improvements, providing for greater reliability and repeatability in field observations are made, including modifications of crown outline classes, absolute heights of vegetative layers, redefinition of leaf size and leaf shape, and so on. Examples of the use of the system(s) for the estimation of biomass are included.

KEYWORDS: Vegetation descriptions; Vegetation structure

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| 1. ORIGINATING ACTIVITY (Corporate author)<br>New York Botanical Garden<br>Bronx Park, Bronx, N. Y. | 2a. REPORT SECURITY CLASSIFICATION<br>Unclassified<br>2b. GROUP |
| 3. REPORT TITLE<br>STUDIES ON THE VEGETATION OF PUERTO RICO | |
| 4. DESCRIPTIVE NOTES (Type of report and inclusive dates)<br>Final report | |
| 5. AUTHOR(S) (First name, middle initial, last name)<br>Pierre Dansereau<br>Peter F. Buell | |

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| 6. REPORT DATE<br>November 1966 | 7a. TOTAL NO. OF PAGES<br>288 p. (incl fwd) | 7b. NO. OF REFS<br>95 |
| 8a. CONTRACT OR GRANT NO.<br>DA-22-079-eng-332<br>b. PROJECT NO.<br>1-V-0-25001-A-131<br>c.<br>d. | 9a. ORIGINATOR'S REPORT NUMBER(S)<br><br>9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)<br>AD 813 748<br>WES Contract Report 3-164 | |
| 10. DISTRIBUTION STATEMENT<br>Approved for public release; distribution unlimited. | | |
| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY<br>U. S. Army Materiel Command<br>Washington, D. C. | |

13. ABSTRACT

Existing vegetation structures, including cultivated types, were examined in the field, in terms of ecological, botanical, and physiognomic characteristics. Sampling ranged from subjective examination to detailed quantitative description, as practiced by the U. S. Army Engineer Waterways Experiment Station. Eight zones, each comprising distinctive aggregations of plant-communities, were identified: Lilloral, Lowland Rainforest, Seasonal Evergreen Forest, Hill Scrub, Semi-deciduous Forest, Lower Montane Rainforest, Montane Forest, and Montane Scrub. Each plant-community in each zone was described in terms of formation type, dominant habit-form, heights of strata, floristic composition and abundance, and site features. A "type physiognomy" was determined for each plant species identified, and recorded in terms of Dansereau descriptors (life-form, leaf size, habit-form, leaf shape, leaf texture, seasonality, dispersal type, and floristic element. Photographs and diagrams illustrate relevés and plant-communities. A detailed map of vegetation physiognomies was constructed for the Roosevelt Roads area by photointerpretation controlled by intensive ground sampling. Almost all basic variations in physiognomy could be detected by photointerpretation.

KEYWORDS: Tropical regions; Vegetation descriptions; Vegetation structure; [Puerto Rico]

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| 1. ORIGINATING ACTIVITY (Corporate author)<br>Geotech, a Teledyne Company<br>3401 Shiloh Road<br>Garland, Tex. | 2a. REPORT SECURITY CLASSIFICATION<br>Unclassified<br>2b. GROUP |

3. REPORT TITLE
RESEARCH, DEVELOPMENT, AND PROTOTYPE PRODUCTION OF AN ULTRAVIOLET SENSING SOIL MOISTURE METER

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
Final report, 1 March 1967-27 August 1967

5. AUTHOR(S) (First name, middle initial, last name)
Jerald B. Cohen

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| 6. REPORT DATE<br>August 1967 | 7a. TOTAL NO. OF PAGES<br>35 | 7b. NO. OF REFS |
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Approved for public release; distribution unlimited.

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| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY<br>Waterways Experiment Station |

13. ABSTRACT

A research program was conducted "to determine feasibility of measuring moisture content of soils by measuring the amount of ultraviolet light transmission through moisture contained in a soil analog encased in a quartz-granule wafer emplaced in the soil." Results obtained from many combinations of soil analogs and system geometry indicate that the concept is operationally impractical. Selected instrumentation developed for the program was reapplied to pursue investigation of promising variations of the initial concept. One variation involved critical angle refractometry. Under laboratory conditions, refractometer-type systems repeatedly yielded signal outputs directly correlative with the percent (moisture) saturation of all soil samples provided. This performance was achieved independent of soil temperature and variations in index of refraction of the soil moisture. Field testing of critical angle refractometers is necessary for establishing the performance of, and specifications for, any operational units. A promising configuration for field test units was prepared.

KEYWORDS: Soil moisture measuring devices; Ultraviolet instruments

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| 1. ORIGINATING ACTIVITY (Corporate author)<br>Department of Soils<br>Oregon State University<br>Corvallis, Oregon | 2a. REPORT SECURITY CLASSIFICATION<br>Unclassified<br>2b. GROUP |
| 3. REPORT TITLE<br>CHARACTERIZATION OF WATER TABLES IN OREGON SOILS WITH REFERENCE TO TRAFFICABILITY; Volume I: DATA | |
| 4. DESCRIPTIVE NOTES (Type of report and inclusive dates)<br>Volume I of final report | |
| 5. AUTHOR(S) (First name, middle initial, last name)<br>Larry Boersma<br>G. H. Simonson | |
| 6. REPORT DATE<br>May 1970 | 7a. TOTAL NO. OF PAGES 235 / 7b. NO. OF REFS 14 |
| 8a. CONTRACT OR GRANT NO.<br>DA-22-079-eng-356<br>b. PROJECT NO.<br>1V021701A046 and 1V025001A131<br>c. Task 02<br>d. | 9a. ORIGINATOR'S REPORT NUMBER(S)<br>9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)<br>AD 870 793<br>WES Contract Report M-70-1, Vol I |
| 10. DISTRIBUTION STATEMENT<br>Approved for public release; distribution unlimited. | |
| 11. SUPPLEMENTARY NOTES<br>Prepared under contract with U. S. Army Engineer Waterways Experiment Station, CE, Vicksburg, Miss. | 12. SPONSORING MILITARY ACTIVITY<br>U. S. Army Materiel Command<br>Washington, D. C. |

13. ABSTRACT

Three near-modal test sites were established on each of the five soil series (Willamette, Woodburn, Amity, Concord, and Dayton) of the Willamette Catena in western Oregon. Field and laboratory tests on soils from the 15 test sites were initiated in the fall of 1963 and terminated in the summer of 1965. The objectives of the study were to (a) determine whether particular water table regimes are associated with specific soil types, (b) achieve the capability for appraising water table regimes from soil morphological information. and (c) gain background knowledge needed in the development of prediction methods for water table depths, soil moisture contents, and soil strengths. Data obtained daily at each site included maximum and minimum air temperatures, precipitation, groundwater depths, and electrical resistance measurement of soil moisture content and temperature. Data obtained periodically included gravimetric soil moisture contents. soil strengths, and the state of the ground and vegetation. Data collected at an opportune time during the course of the study included Atterberg limits. grain-size distributions, specific gravities, organic matter contents. moisture contents at specified tensions, dry densities, site descriptions, and soil profile descriptions. The data above have been condensed in tabular and graphic form for presentation herein. Also included are brief descriptions of the geology, topography, physiography, climate, soils, and land use of the study area. Corrected soil moisture unit readings and corresponding gravimetric soil moisture measurements are included in Appendix A. An analysis of the data is to be presented in Volume II of this report.

KEYWORDS: Trafficability; Water table prediction; Water tables data; [Oregon]

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| 1. ORIGINATING ACTIVITY (Corporate author)<br>Department of Soils, Oregon State University<br>Corvallis, Oregon | 2a. REPORT SECURITY CLASSIFICATION<br>Unclassified<br>2b. GROUP |

3. REPORT TITLE

CHARACTERIZATION OF WATER TABLES IN OREGON SOILS WITH REFERENCE TO TRAFFICABILITY;
Volume II: ANALYSIS

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Volume II of final report

5. AUTHOR(S) (First name, middle initial, last name)

Larry Boersma
G. H. Simonson
D. G. Watts

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| 6. REPORT DATE<br>May 1970 | 7a. TOTAL NO. OF PAGES<br>108 | 7b. NO. OF REFS<br>8 |
| 8a. CONTRACT OR GRANT NO.<br>DA-22-079-eng-356<br>b. PROJECT NO.<br>1V021701A046 and 1V025001A131<br>c.<br>Task 02<br>d. | 9a. ORIGINATOR'S REPORT NUMBER(S)<br><br>9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) AD 870 796<br>WES Contract Report M-70-1, Vol II | |

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| 11. SUPPLEMENTARY NOTES<br>Prepared under contract with U. S. Army Engineer Waterways Experiment Station, CE, Vicksburg, Mississippi | 12. SPONSORING MILITARY ACTIVITY<br>U. S. Army Materiel Command<br>Washington, D. C. |

13. ABSTRACT

Three near-modal test sites were established on each of the five soil series (Willamette, Woodburn, Amity, Concord, and Dayton) of the Willamette drainage sequence in western Oregon. Field and laboratory tests on soils from the 15 test sites were initiated in the fall of 1963 and terminated in the summer of 1965. The objectives of the study were to (a) determine whether particular water table regimes are associated with specific soil types, (b) achieve the capability for appraising water table regimes from soil morphological information, and (c) gain background knowledge needed in the development of prediction methods for water table depths, soil moisture contents, and soil strengths. Data obtained daily at each site included maximum and minimum air temperatures, precipitation, groundwater depths, and electrical resistance measurements of soil water content and temperature. Data obtained periodically included gravimetric soil water contents, soil strengths, and the state of the ground and vegetation. Data collected at opportune times during the course of the study included Atterberg limits, grain-size distributions, specific gravities, organic matter contents, water contents at specified tensions, dry densities, site descriptions, and soil profile descriptions. These data have been presented in Volume I of the report. The analysis of the data is presented herein. Included is a frequency analysis of the occurrence of certain water table conditions. The frequency and duration of certain water table conditions are related to morphological soil profile characteristics. It is shown how water table regimes may be inferred from morphological information.
KEYWORDS: Soil analysis; Trafficability; Water table prediction; Water tables; [Oregon]

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**1. ORIGINATING ACTIVITY (Corporate author)**
The Florida State University
Tallahassee, Florida

**2a. REPORT SECURITY CLASSIFICATION**
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**2b. GROUP**

**3. REPORT TITLE**
A STUDY TO DEVELOP METHODS FOR THE ANALYSIS OF THE FINE STRUCTURE OF SEA-LAND BOUNDARY ZONES

**4. DESCRIPTIVE NOTES (Type of report and inclusive dates)**
Contract Report

**5. AUTHOR(S) (First name, middle initial, last name)**
Stevenson, Robert E.
Warnke, Detlef A.

| 6. REPORT DATE | 7a. TOTAL NO. OF PAGES | 7b. NO. OF REFS |
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**9a. ORIGINATOR'S REPORT NUMBER(S)**

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**10. DISTRIBUTION STATEMENT**
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**11. SUPPLEMENTARY NOTES**
App. A, Photographs; App. B, Maps & Overlays; App. C, Profiles; App. D, Trafficability Data; App. E, Vegetation Data; App. F, Vegetation Data

**12. SPONSORING MILITARY ACTIVITY**
WES

**13. ABSTRACT**
This report is based on studies of 11 sites in the Big Bend area of northwest Florida and four sites in the Florida Keys. For each site, parallel profiles perpendicular to the shoreline and spaced at 5- to 10-meter intervals were constructed, and for most sites radial profiles at 15° intervals were also prepared. Investigations were made of surface geometry, soils trafficability, and vegetation in connection with the beach sites, using the pre-existing WES sampling techniques and descriptive systems. Contour maps, showing location of the profiles, vegetation, and locations where trafficability data were taken, were prepared for each site. A descriptive and a classification system are developed. Appendices contain large-scale contour maps and profiles of each site, trafficability and vegetational data, and aerial and ground photographs. A detailed discussion of alternative field methods used, with their relative advantages and disadvantages is presented. The following conclusions are stated: (a) The land-sea boundary zone represents a unique factor family. Setting it apart are the constant changes which it undergoes, the most important of which are tidal fluctuations, and the linearity of structural elements. (b) Most beaches and tidal flats consist of fine sand with a median diameter of 0.3 mm. Sorting on the beaches is excellent, poorer on the tidal flats. (c) Cone penetrometer readings on all the beaches are highly erratic. Tables, maps, illustrations. Six appendices.

KEYWORDS: Beach terrain; Beach trafficability; Land-water interface; Surface geometry; Trafficability; Vegetation; [Florida]

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ENVIRONMENTAL STUDIES OF PROTECTED SEA-LAND BOUNDARY ZONES ALONG THE WEST COAST OF FLORIDA

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

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5. AUTHOR(S) (Last name, first name, initial)

Stevenson, Robert E.
Warnke, Detlef A.

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10. AVAILABILITY/LIMITATION NOTICES

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| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY<br>WES |

13. ABSTRACT This report covers the study of 12 sea-land boundary sites on the western side of peninsular Florida. The sites were chosen to be representative of low-energy, marshy coasts. The report presents verbal descriptions of the sites in terms of topography, vegetation, soils, and trafficability. Detailed strip maps portraying these factors, with a "characteristic central profile," are given in an appendix. However, the sites are not classified by the system presented in the previous report, nor is any mention made of this system. Photographs, as well as detailed data on soils trafficability and vegetation analyses, are given in appendices. The following conclusions are presented: (a) Environment of the study area is a resultant of the geology and climate, and of the vegetation produced by geology and climate. (b) The sites are made up of the following elements: tidal flats, topographic highs (barlike features) separating tidal flats from marshes; marshes with tidal channels and hammocks (topographic highs with dense vegetative cover). (c) Soils are predominantly poorly graded sands with admixtures of peat in the marshes, which latter become critical trafficability obstacles. Limestone outcrops occur in the tidal flats and hammocks. (d) The sea-land boundary zone can be relatively easily penetrated by personnel familiar with the terrain. (e) The tides on the investigated area are mixed. Tidal ranges are about 1 meter, but higher and lower ranges occur. Velocities and directions of current in the tidal channels are erratic. Tables, maps, illustrations and appendices.

KEYWORDS: Beach terrain; Beach trafficability; Land-water interface; Marshes; Surface geometry; Trafficability; Vegetation; [Florida]

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| *(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)* | | |
| 1. ORIGINATING ACTIVITY (Corporate author)<br>Rice University<br>Department of Geology<br>Houston, Texas 77001 | 2a. REPORT SECURITY CLASSIFICATION<br>Unclassified<br>2b. GROUP | |
| 3. REPORT TITLE<br>DEVELOPMENT OF REMOTE METHODS FOR OBTAINING SOIL INFORMATION AND LOCATION OF CONSTRUCTION MATERIALS USING GAMMA RAY SIGNATURES FOR PROJECT THEMIS | | |
| 4. DESCRIPTIVE NOTES (Type of report and inclusive dates)<br>Semi-annual report, 2 volumes | | |
| 5. AUTHOR(S) (First name, middle initial, last name) | | |
| 6. REPORT DATE<br>December 1970 | 7a. TOTAL NO. OF PAGES<br>175 | 7b. NO. OF REFS<br>15 |
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| 10. DISTRIBUTION STATEMENT<br>Approved for public release; distribution unlimited. | | |
| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY<br>U. S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi 39180 | |

13. ABSTRACT


The research described herein is directed toward three main end uses: ( 1) terrain analysis, including the characterization of soils and rocks on the basis of their thorium, uranium, and potassium contents; trafficability; building materials, e.g. limestone with optimum clay content for cement; soil moisture; (2) direct exploration for economic deposits of thorium and uranium; indirect mineral exploration for minerals associated with radioactive minerals, e.g. placer gold, or with potassium alteration, e.g. copper; (3) rapid location and assessment of fission product contamination of the environment.

A complete full scale field systems test operation has been completed in Puerto Rico and the evaluation of this test demonstrates that the first order calibration enables one to characterize the soil developed from each major geologic formation on the basis of its gamma spectrometric signature. Much of the beach on Puerto Rico accurately reflects the gamma spectrometric signatures of the source rocks in the hinterland of each particular beach.



KEYWORDS: Gamma ray spectrometer; Gamma rays; Remote sensing; Terrain analysis;[Puerto Rico]


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| 1. ORIGINATING ACTIVITY (Corporate author)<br>Rice University<br>Department of Geology<br>Houston, Texas | 2a. REPORT SECURITY CLASSIFICATION<br>Unclassified<br>2b. GROUP |

3. REPORT TITLE

DEVELOPMENT OF REMOTE METHODS FOR OBTAINING SOIL INFORMATION AND LOCATION OF CONSTRUCTION MATERIALS USING GAMMA RAY SIGNATURES FOR PROJECT THEMIS

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Ammual report

5. AUTHOR(S) (First name, middle initial, last name)

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10. DISTRIBUTION STATEMENT

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|---|---|
| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY<br>U. S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi 39180 |

13. ABSTRACT

A survey of an area near Stillwater, Oklahoma, emcompassing field, laboratory, and aerial measurements, indicates that while the Oklahoma soils surveyed show less natural variability in their gamma-ray signatures than the residual soils of Puerto Rico, it is generally possible to distinguish between areas of different soil types and often to identify particular soils by their characteristic concentrations of K, U, and Th. Besides providing the first full field test of the Mark III gamma-spectrometer and demonstrating the time-saving necessity for an incremental tape-recorder, a direct comparison was made available between the Mark III helicopter system and the fixed-wing Texas Instruments system. As would be expected this comparison showed that our low-altitude measurements gave much higher ground resolution, with sharper demarcation of soil boundaries and more detailed traces of the gamma-ray variations within soil types.

KEYWORDS: Gamma ray spectrometer; Gamma rays; Remote sensing; Terrain analysis; [Stillwater, Oklahoma]

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|---|---|
| 1. ORIGINATING ACTIVITY *(Corporate author)*<br>Rice University<br>Department of Geology<br>Houston, Texas 77001 | 2a. REPORT SECURITY CLASSIFICATION<br>Unclassified<br>2b. GROUP |

3. REPORT TITLE

DEVELOPMENT OF REMOTE METHODS FOR OBTAINING SOIL INFORMATION AND LOCATION OF CONSTRUCTION MATERIALS USING GAMMA RAY SIGNATURES FOR PROJECT THEMIS

4. DESCRIPTIVE NOTES *(Type of report and inclusive dates)*

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5. AUTHOR(S) *(First name, middle initial, last name)*

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| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY<br>U.S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi 39180 |

13. ABSTRACT

An experimental comparison of NaI (Tl) and solid organic scintillation detectors for use in remote sensing of terrestrial gamma rays is presented. The results demonstrate that organic detectors can be used for this purpose with the added advantages of being less expensive and more rugged.

KEYWORDS: Gamma ray spectrometer; Gamma rays; Remote sensing; Terrain analysis

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3. REPORT TITLE

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4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

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5. AUTHOR(S) (First name, middle initial, last name)

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10. DISTRIBUTION STATEMENT

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| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY<br>U. S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi 39180 |

13. ABSTRACT

The Mark III gamma-spectrometer system was completed with parallel strip chart and incremental magnetic tape recording of 6 channels of information. The modular design of this system permits flexibility as to power source (battery or aircraft) and as to what gamma-spectrometric, aeromagnetic, and altitude information is recorded along with fiducial event marking. It is now possible with the theory developed in this project to predict with considerable confidence given a particular topography and sought gamma-spectrometric signature what altitude, ground speed, and type of volume of detector are required. A theoretical study was made of the feasibility of using the Mark III system to survey the structures in Grand Junction, Colorado, that were contaminated with uranium mill tailings. It was concluded that the Mark III system could detect with 90% confidence town lot targets averaging 50 to over 100 microrems/hour, which are the levels of concern designated by the Surgeon General.

KEYWORDS: Gamma ray spectrometer; Gamma rays; Remote sensing

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4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

5. AUTHOR(S) (First name, middle initial, last name)

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| 11. SUPPLEMENTARY NOTES<br>Includes program and abstracts of the natural radiation environment symposium II held in August 1972. | 12. SPONSORING MILITARY ACTIVITY<br>U.S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi 39180 |

13. ABSTRACT


Emanation characteristics of rocks, soils and RN-222 loss effect on the U-PB system discordance; RADON-222 emanation characteristics of lunar fines; program and abstracts natural radiation environment 2.



KEYWORDS: Gamma ray spectrometer; Gamma rays; Lunar soils; Remote sensing; Terrain analysis


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Meyer, Marvin P

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